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# Metal Progress

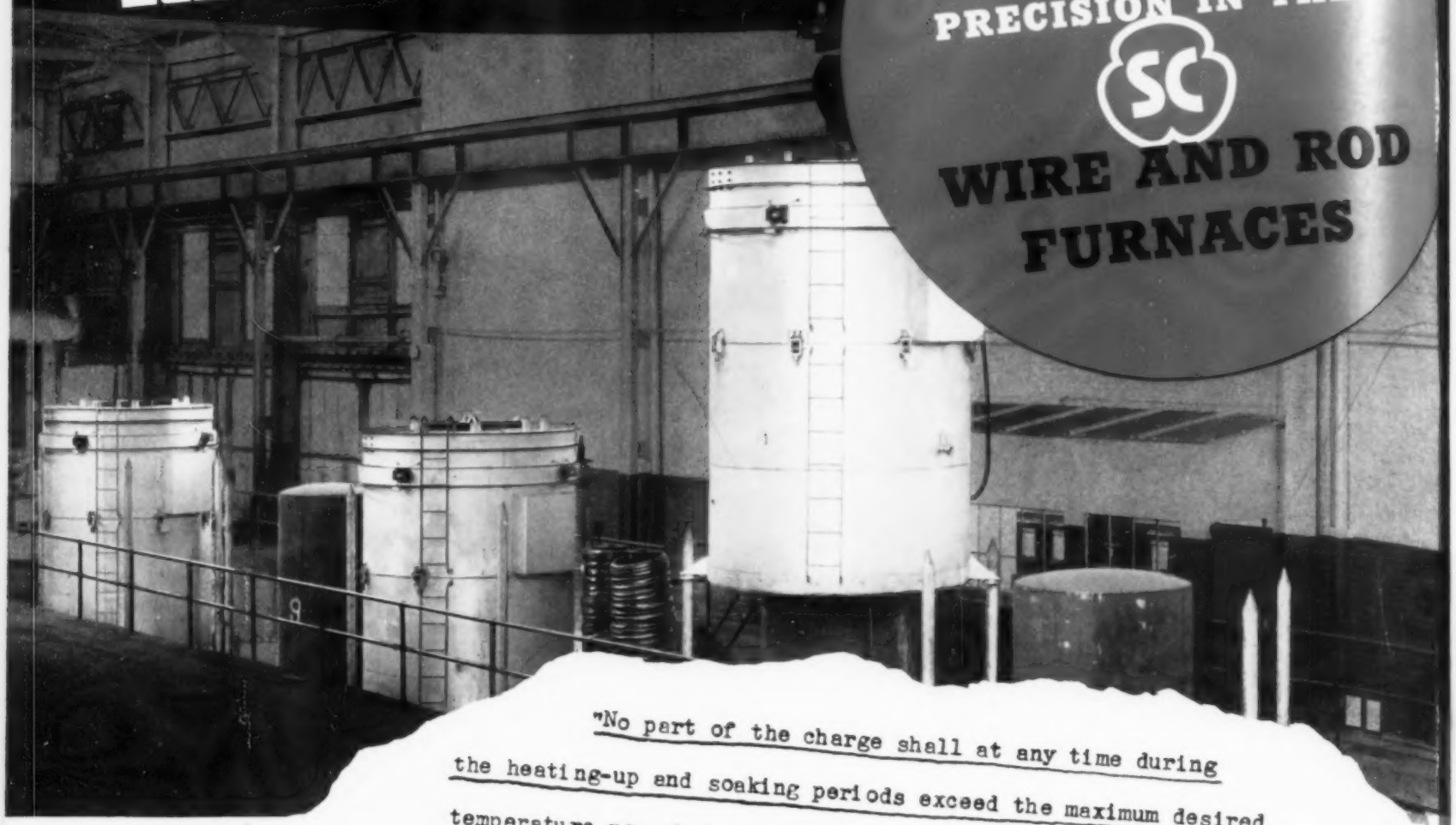
## December · 1940

# RIGID SPECIFICATIONS

MET WITH EASE AND PRECISION IN THESE

SC

WIRE AND ROD FURNACES



"No part of the charge shall at any time during the heating-up and soaking periods exceed the maximum desired temperature nor shall the differential between any portions of the charge exceed 25°F. after the desired control temperature is reached - the cooling rate shall be 5° to 100°F. per hour down to [CENSORED] °F."

(EXCERPT FROM SPECIFICATIONS OF WELL-KNOWN MANUFACTURER)

SECURITY FOR AMERICA

SC FURNACES FOR NATIONAL DEFENSE

● Such were the specifications in part of a large wire and rod manufacturer when asking for bids on eight radiant tube covers for annealing, normalizing, and spheroidizing. It was easy to meet these specifications with Surface Combustion Radiant Tubes. The exclusive feature of long flame travel — made possible by progressive semi-diffusion combustion — permits adjustment of temperature distribution and rapid heating without over-heating . . . The illustration shows some of the eight covers comprising this one installation. Both low and high carbon steel, and low and high carbon alloy steel are heat treated. Each base will accommodate a charge up to 7000 pounds. With a cold cover, a charge of 4800 pounds can be heated to 1380° F. in five hours without overheating the outside strands. On such a heat the fuel consumption is between 1,000,000 and 1,250,000 Btu's per ton. With a hot cover the fuel consumption and heating time is considerably less . . . Write for additional information.

SURFACE COMBUSTION CORPORATION . . . TOLEDO, OHIO

WHEREVER HEAT IS USED IN INDUSTRY

SC 34 YEARS

# SURFACE COMBUSTION

MANUFACTURERS OF INDUSTRIAL FURNACES • JANITROL GAS-FIRED SPACE HEATING EQUIPMENT • AND KATHABAR AIR CONDITIONING SYSTEMS

# SPEED WHEN IT'S NEEDED...

# NEW TOCCO JUNIOR HARDENS 600 AREAS PER HOUR ON 100 ROCKER SHAFTS

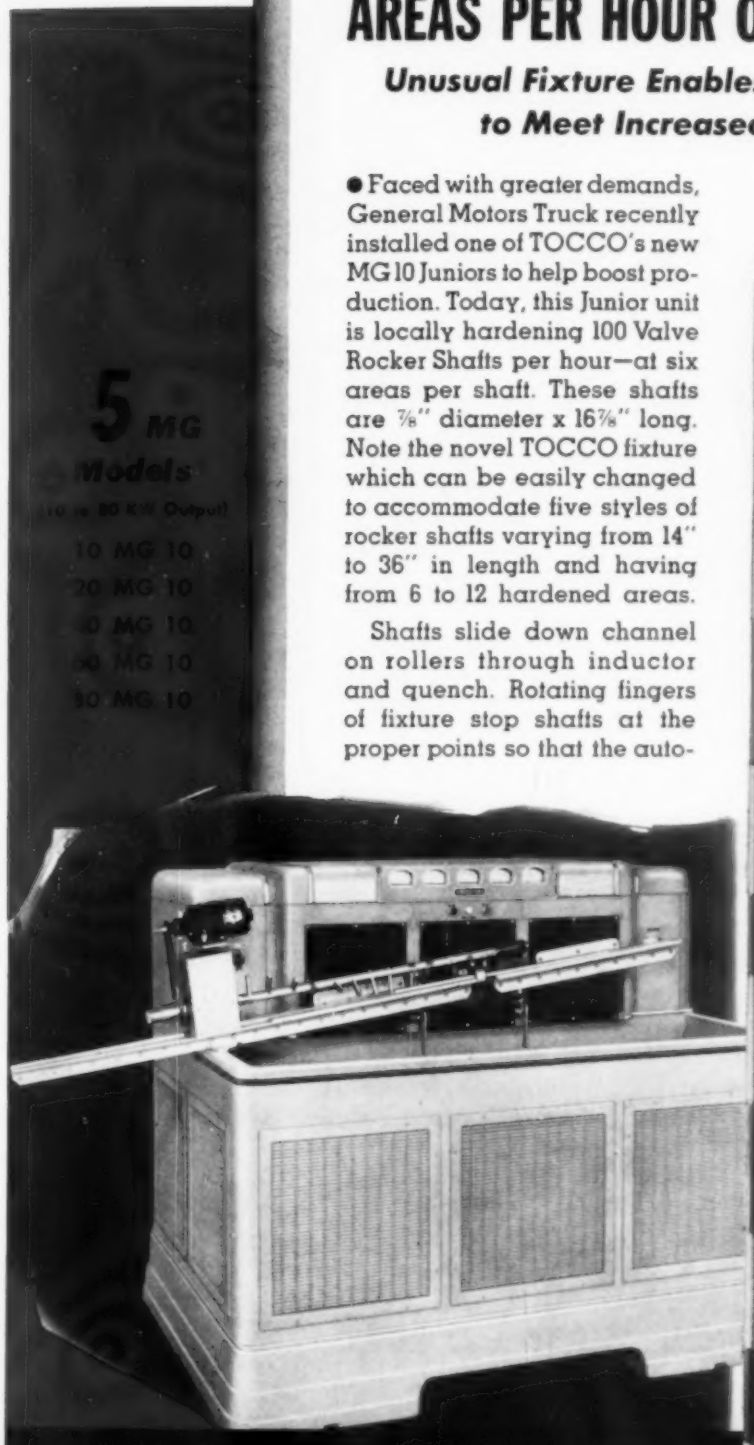
***Unusual Fixture Enables Leading Truck Manufacturer to Meet Increased Production Schedules***

● Faced with greater demands, General Motors Truck recently installed one of TOCCO's new MG 10 Juniors to help boost production. Today, this Junior unit is locally hardening 100 Valve Rocker Shafts per hour—at six areas per shaft. These shafts are ⅞" diameter x 16⅞" long. Note the novel TOCCO fixture which can be easily changed to accommodate five styles of rocker shafts varying from 14" to 36" in length and having from 6 to 12 hardened areas.

Shafts slide down channel on rollers through inductor and quench. Rotating fingers of fixture stop shafts at the proper points so that the automatic heating and quenching harden the specified areas. The hardness is closely and accurately controlled. There's no scale, dirt or distortion—and skilled labor is not essential. Here's surface hardening at its best—and fastest!

All of TOCCO's five new MG 10 Junior models are self-contained, with high frequency motor generator sets and full pre-set automatic controls. Occupying but 5' x 6' 8" of floor space, you can install the new Junior quickly in a production line. There, it will reduce former handling costs between heat-treat department and machining line. MG Juniors can be furnished with one to three hardening stations and a variety of fixtures for localized surface hardening of many different parts.

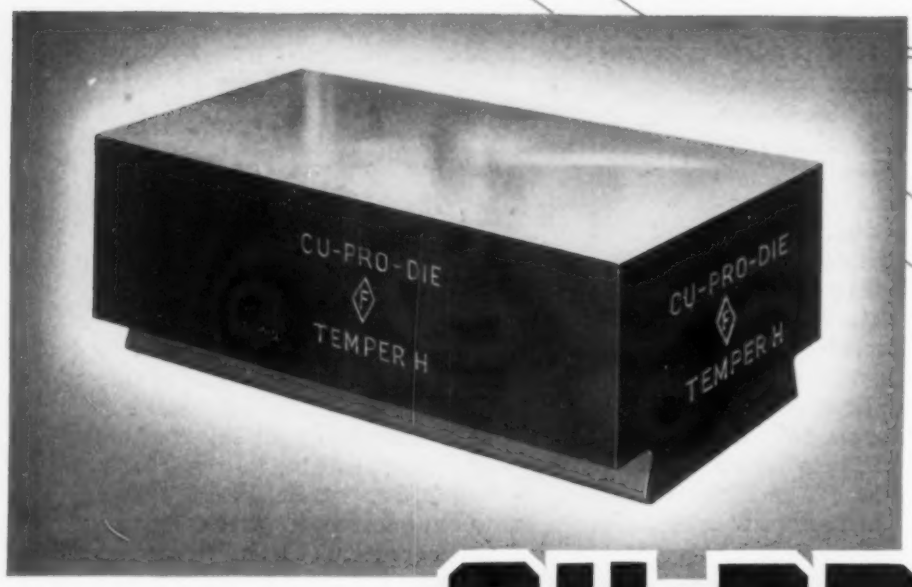
If you are a small-parts manufacturer and wish to reduce heat-treating costs while speeding up production, it will pay you to investigate the TOCCO MG 10 Junior. Write for full information—and learn how TOCCO does it.

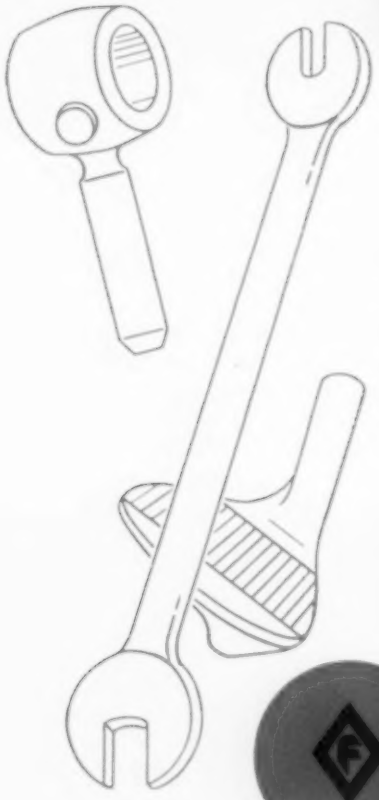



40 MG 10 TOCCO Junior

THE OHIO CRANKSHAFT [illegible]PANY
CLEVELAND, OHIO

» *WHY* use <u>annealed</u> die blocks when there's a "tailor-made", heat-treated, die block that serves your purpose *<u>better</u>* for many jobs?



# CU·PRO·DIE

## TEMPER H

**(*Face Hardness: 66-62 Scl. = 477-444 B.N.)**
**(Shank Hardness: 55 Scl. Max. = 375 B.N. Max.)**

YOU no longer have to produce thin-section forgings (such as illustrated) in annealed and hardened die blocks. Impressions can be sunk in FINKL'S newest block in the high range of hardness indicated.* The special-drawn shanks machine readily. ● So . . . why assume the risk nealed blocks? What of the lost and expense of hardening ansions? CU-PRO-DIE eliminates all time correcting warped impresthese troubles!

This grade of block is also furnished in:

| | |
|---|---|
| TEMPER No. 1 | 60-56 Scl. = 423-388 B. N. |
| TEMPER No. 2 | 55-52 Scl. = 375-352 B. N. |
| TEMPER No. 3 | 51-48 Scl. = 341-321 B. N. |

<u>Convince yourself. Give CU-PRO-DIE a trial.</u>

**A. FINKL & SONS CO.**
CHICAGO • ILLINOIS

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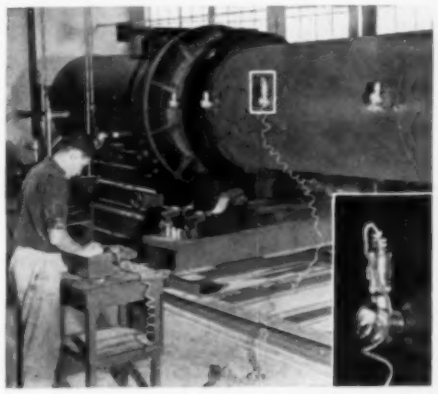
## New Device Helps Measure Heat of Rotary Kiln

An easy way to check the temperature gradient along a rotary kiln, without using slip-rings to connect couples to the portable pyrometer, has just been worked out in connection with a Sherwin-Williams Company semi-plant unit.



Couples in rotary kiln. Insert is close-up of area in small rectangle.

The kiln is about 20 feet by 7, and turns at a few revolutions per hour. Thermocouples are installed along its side, using our standard protecting tubes and Universal couple heads. On each head, however, is a new type of special pin-plug terminal. Leadwires from the L&N Portable Temperature Indicator (No. 8657-C) end in receptacles for these plugs and can thus be snapped onto the heads as soon as they revolve into position. They only "fit" in the correct polarity; the operation is so swiftly done that the entire half-dozen couples can be checked before the kiln carries the heads out of reach. The kiln operator, with these readings to keep him informed, can regulate the burners to put maximum heat at the correct point in the kiln. He also has a multipoint Micromax recording pyrometer which gives permanent records of temperatures in the kiln's combustion and exit chambers.

Information regarding a specific application of these instruments will be sent on request.

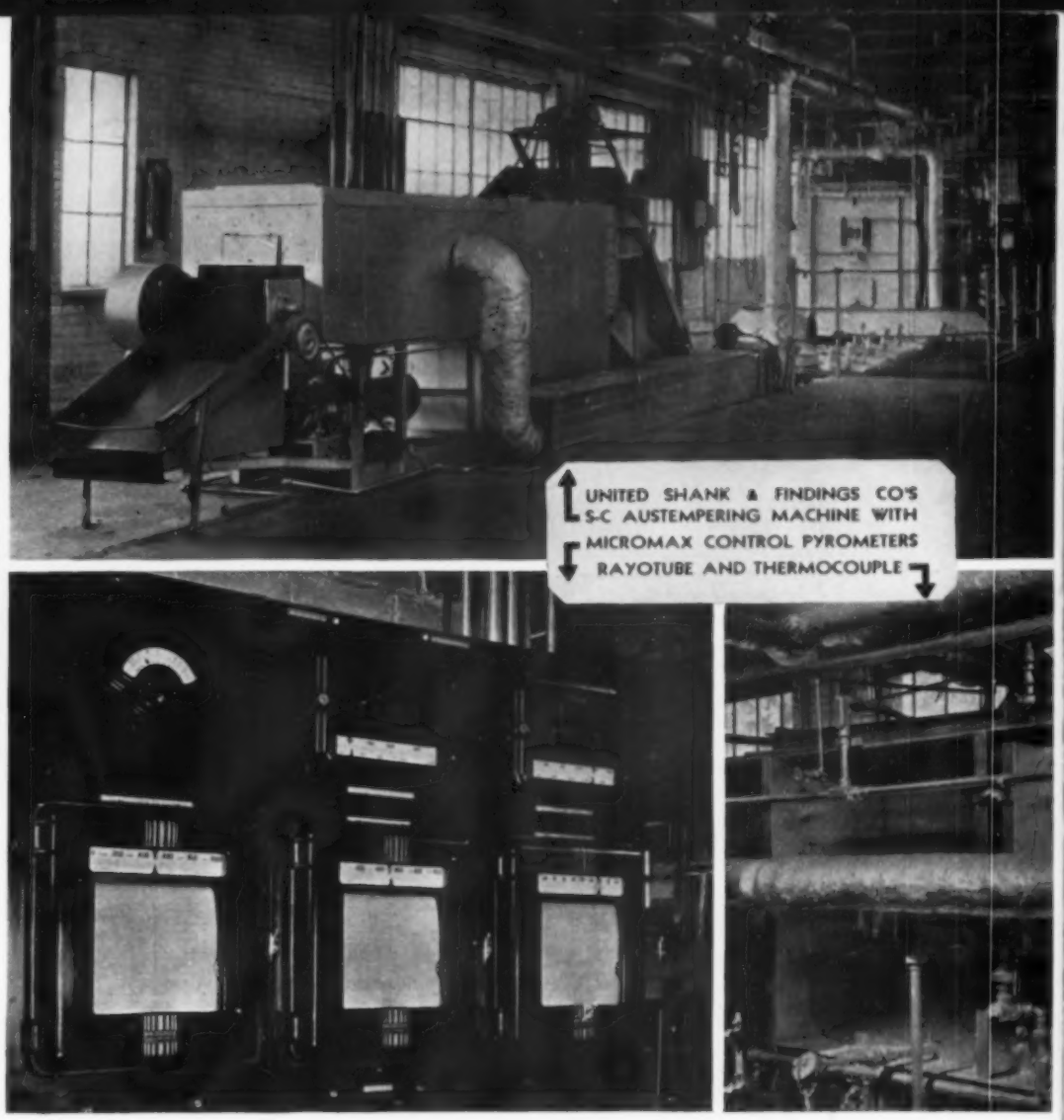
## *"Instruments Pay" Says Caterpillar Engineer*

"We have a total of 300 instruments in our various heat-treating operations, exclusive of those in the laboratories" writes Charles E. Armstrong, Plant Engineer of Caterpillar Tractor Co., at Peoria, Ill., in the magazine *Factory Management & Maintenance* for October.

"The point of having all this equipment" Mr. Armstrong continues, "is that it permits precise regulation of temperatures . . . fuel savings . . . and reduces rejections on Brinell and similar inspections."

Caterpillar feels that "any one of the three savings is more than sufficient to pay for the instrumentation including carrying charges and the instrument men's salaries."

The article cites a case in which Caterpillar overcame a tendency of batch-type furnaces to overheat at one end. Other cases concern cyanide pots, low-temperature furnaces, and high temperature equipments. Each is explained in clear, non-technical words and the remedy is similarly given. Illustrations show some of the control equipment employed.




# MICROMAX PYROMETERS *Control* HEAT IN BIG AUSTEMPERING MACHINE

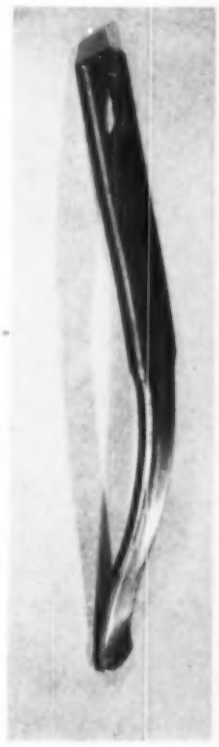
## Orders Various Temperatures In Various Ways To Meet Heat-Treating Needs

Each hour from 500 to 700 lbs of flat steel springs are heat-treated in the austempering equipment shown above. The springs are hardened in controlled atmosphere, quenched in salt, washed, rinsed and dried. There's no scale; original surface is intact; hardness is 54-56 Rockwell C.

The varied needs of pyrometric control are met by Micromax pyrometers and accessories: To make sure the parts are hot enough when quenched, a "Rayotube", which "looks in" directly at them, and is considerably more responsive than the usual thermocouple, is focused on them. Since no record is needed here, the Rayotube is connected to a Micromax non-recording controller. Other temperatures are detected by thermocouples, with either Micromax recording controllers or non-recorders, to supply the desired information.

Despite varied requirements, only one type of valve-drive is used — the Micromax Electric. Each meets perfectly its load and lag situation, and gives full Micromax sensitivity from couple to valve.

For general information about dependable control, write for Catalogs N-33A and N-00B.



→ Before austempering and after—steel springs show no distortion, no scale, no decarb

LEEDS & NORTHRUP COMPANY, 4927 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl Ad ENT-0600C(7)

YOUR COMMERCIAL HEAT TREATING

# GUIDE

One of these established companies is as conveniently available as your telephone. Let this expert solve those unusual heat treating problems—or call him in to do the complete job, including carburizing, cyanide hardening, nitriding, tool, die, high speed steel and high carbon chrome steel hardening.

**BOSTON**
New England Metallurgical Corporation
8 ALGER STREET · SOUTH BOSTON 3313

**CHICAGO**
Accurate Steel Treating Company
2286 W. HUBBARD ST. · SEELEY 7393

Perfection Tool & Metal Heat Treating Co.
1740 W. HUBBARD ST. · HAYMARKET 2024-5-6

Lindberg Steel Treating Company
318 N. LAFLIN STREET · MONROE 3911

**CINCINNATI**
The Queen City Steel Treating Company
2970 SPRING GROVE AVE. · KIRBY 3161

**CLEVELAND**
The Lakeside Steel Improvement Company
5418 LAKESIDE AVE. · HENDERSON 9100

**DETROIT**
Commercial Steel Treating Corporation
6100 TIREMAN AVE. · TYLER 6-6088

Commonwealth Industries
5922 COMMONWEALTH AVE. · MADISON 8573

**ELIZABETH, N. J.**
American Metal Treatment Company
ELIZABETH 2-2121

**MILWAUKEE**
Wesley Steel Treating Company
1321 W. PIERCE STREET · MITCHELL 8707

**NEW YORK**
Heinzelman's Heat Treating Hardening Wks., Inc.
154 SPRING STREET · WALKER 5-2666

**PHILADELPHIA**
Lorenz & Son
1400 N. FRONT ST. · REGENT 7722 EAST 8355

Metlab Co. (Metallurgical Laboratories, Inc.)
1000 E. MERMAID LANE · CHESTNUT HILL 3500

Wiedemann Machine Company
1901-31 SEDGLEY AVE. · SAGAMORE 3027
PARK 2258

**PITTSBURGH**
Pittsburgh Commercial Heat Treating Company
3708 LIBERTY AVE. · SCHENLEY 2188


# Heat Treating Progress

## Now If Ever . . .

"NOW IF EVER—"—the commercial steel treating industry has an opportunity to justify its existence. We believe that this industry will be found ready to handle the tremendous load which is to be placed on it by the Defense Program. For years the commercial steel treater has built up his equipment and personnel to handle metal treating problems with a combination of speed and accuracy. Further expansion is already taking place. He has the one asset most important of all in times such as these—years of experience in almost every one of the processes required in the manufacture of defense materials.

These times may bring new heat treating problems to your organization, but your telephone can bring you the representative of a nearby commercial steel treating plant who has already had the headaches and who has long ago found the solution to such problems — the proper equipment, the proper materials, the most efficient methods of handling. Every manufacturer in the metal industry will have plenty of worries in the days ahead without unnecessarily adding the complex problems of heat treating, and the expensive equipment necessary. Now is the time to take advantage of the commercial steel treater's experience. Now if ever.

W. G. HAMILTON
*President*
Accurate Steel Treating Co.
Chicago, Illinois

# "Yes, Dear, it's a pretty hat!"

● Indeed, it is a pretty hat—but Jim, the foreman at the Accurate Steel Treating Company, doesn't have his mind on hats. Yes, he agreed to go with his wife on her Thursday evening shopping tour—but darned if he can get his mind on it. What he is really thinking about is that job for the Jasper A. Potts Company. It won't be in the shop until 9:00 in the morning, and the customer wants it in time to ship on the 3:30 plane for San Francisco tomorrow afternoon.

In the back of his mind Jim is picturing just whom he will put on the job. Perhaps he will do it himself, for he realizes that his friend George at the Potts Company is really behind the eight ball, and just has to have the job in an unusually short time. Jim's glad to put forth a little extra effort, for he feels that it is part of his job to help his friends out of occasional tight spots.

We here at the Accurate Steel Treating Company, are proud of Jim, for we know that he puts forth that extra effort not because he has to, but because he wants to. We are all Jims here—everyone from the foreman across the organization to the boss' beautiful blond secretary.

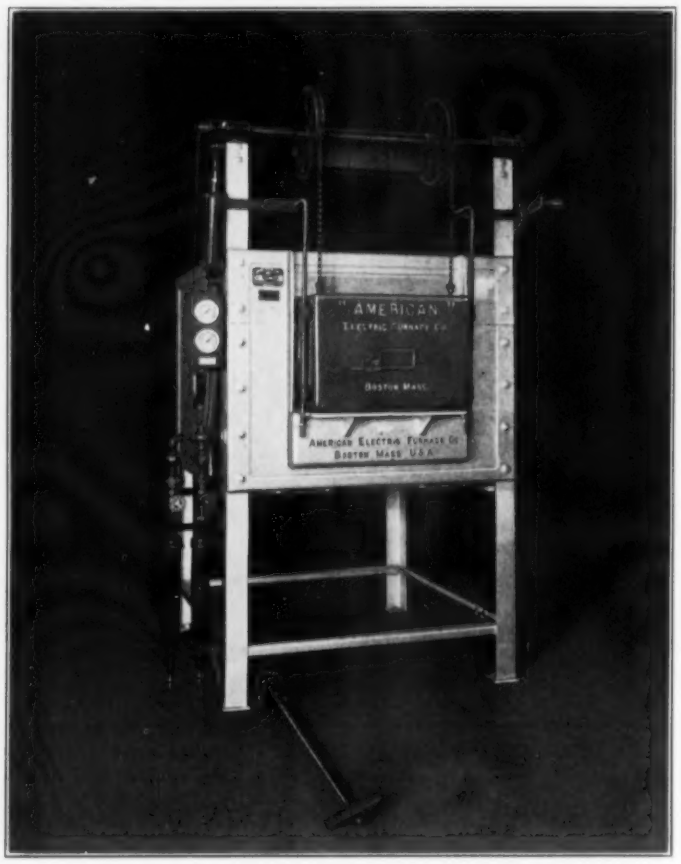
Here you'll find that strange combination of a cordial personalized service, and a snappy efficiency that turns out faultless work at a sprint-like pace. We'd like to be friends with you. Won't you call us some day, or better yet, drop in at the plant?

# ACCURATE

## STEEL TREATING COMPANY

**2226 West Hubbard Street, Chicago, Illinois • Telephone SEEley 7393**

# U. S. Defense DEMANDS
## modern heat treating furnaces




New B1630 Furnace with Synchronous Atmospheric Control and Air Operated Door. Chamber 16" Wide, 30" Deep, 12" High.

"AMERICANS" meet this demand in full.

"AMERICANS" have:

Maximum Efficiency

Synchronous Atmospheric Control

Rapid Heating

Simplified Operation

Minimum Heat Losses

"AMERICANS" will:

Give Superior Results

Increase Production

Reduce Operating Costs

Improve Working Conditions

Profit from the experience of our leading arms manufacturer

For years the daily use of "AMERICAN" Electric Furnaces has been of major importance in meeting rigid government specifications. The results were so

successful that the large number of furnaces ordered for current programs were ALL "AMERICAN" Electric.

Write Today for Bulletins and Prices

**American Electric Furnace Company**

30 VON HILLERN ST. ★ BOSTON, MASS., U. S. A.

Industrial Furnaces for All Purposes

MEMO
FROM THE OFFICE OF THE PRESIDENT
Jim —
I suggest you consider Copperweld Steel, Warren, Ohio, for a part of our alloy steel requirements.
I understand they have a fine bunch of experienced steel makers working in a new plant built solely for the production of alloy steels.
Let's give them a trial — I'd like to find out if they're as good as I've heard they are.
W. F.
ARISTOLOY STEELS
ARISTOLOY STEELS
S.A.E. ALLOY BILLETS AND BARS; OXIDATION AND CORROSION RESISTING STEELS; TOOL AND SPECIAL STEELS; AIRCRAFT QUALITY STEELS; STAINLESS STEELS
COPPERWELD STEEL COMPANY · WARREN, OHIO

YOUR COMMERCIAL HEAT TREATING

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2710 LIBERTY AVE. · SCHENLEY 2188

# Heat Treating Progress

## One Word Please

WHY, according to records, does a large percentage of the enterprising industries leave their heat treating problems to the commercial steel treaters like those mentioned at the left of this column?

WHY? Because experienced manufacturers have found it is not possible, either from a productive, performance, or cost standpoint, to produce results at all comparable to those obtained by commercial steel treaters.

WHY? Because the commercial steel treater, being experienced in one line of endeavor, must obviously retain only the latest type of equipment, and gains an invaluable experience by constant research and actual practice.

WHY? Because without a continuous production volume to keep both men and furnaces busy, the operating cost would exceed many times the price charged by the commercial steel treater.

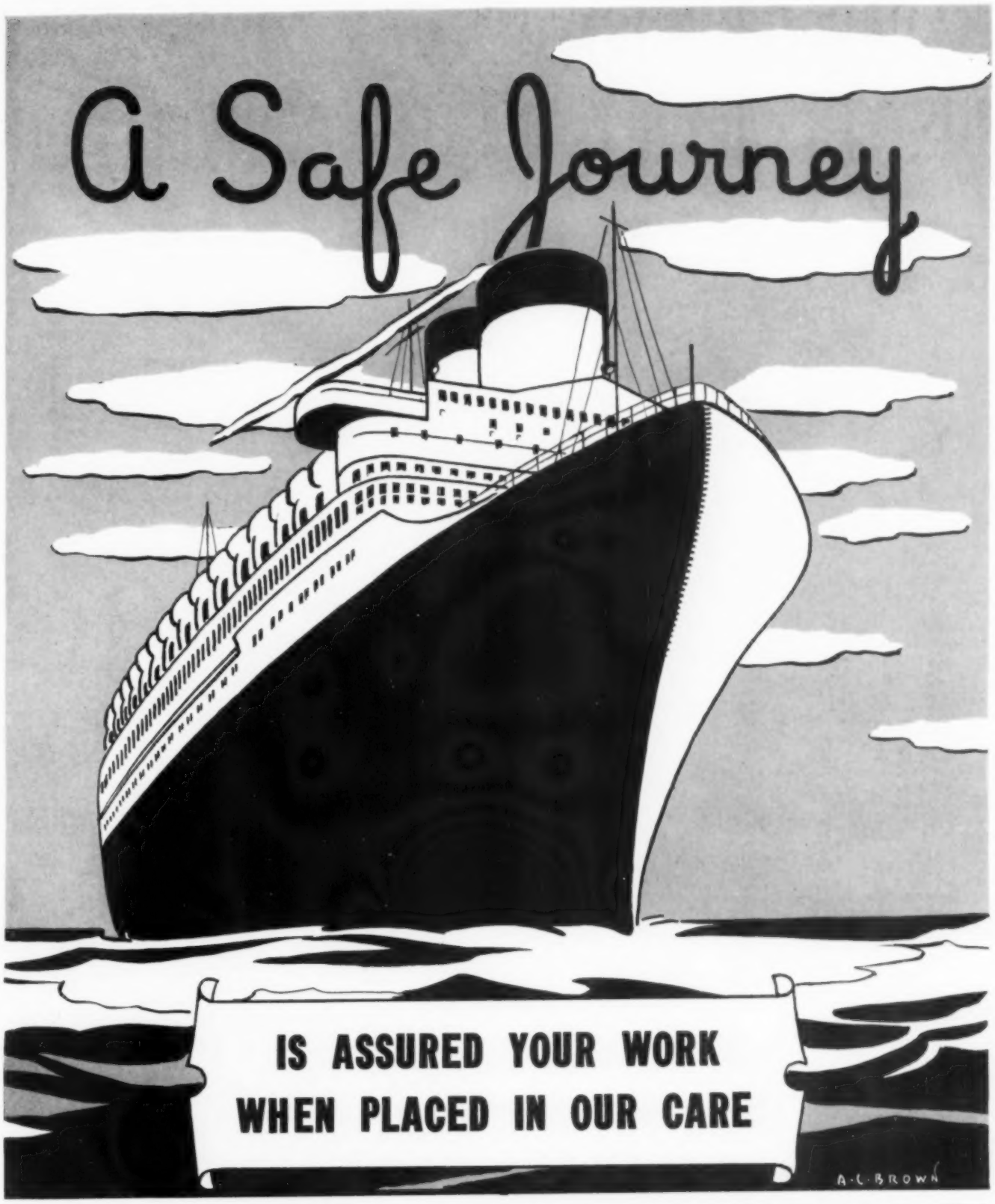
WHY? Because they realize that the steel treater, only by doing the work collectively for many concerns, can offer them a high quality of workmanship and service at a low figure.

WHY? Because the heat treater's experience is so diversified that he can safely handle any variety of work, from large body dies to the most intricate jeweler's dies.

WHY? Because they have no capital investment which in itself would be much more costly to maintain than any amount expended for heat treating.

WHY? Because with an aim to serve, thereby satisfying their requirements to the fullest, we welcome their inquiries regarding any heat treating problems confronting them.

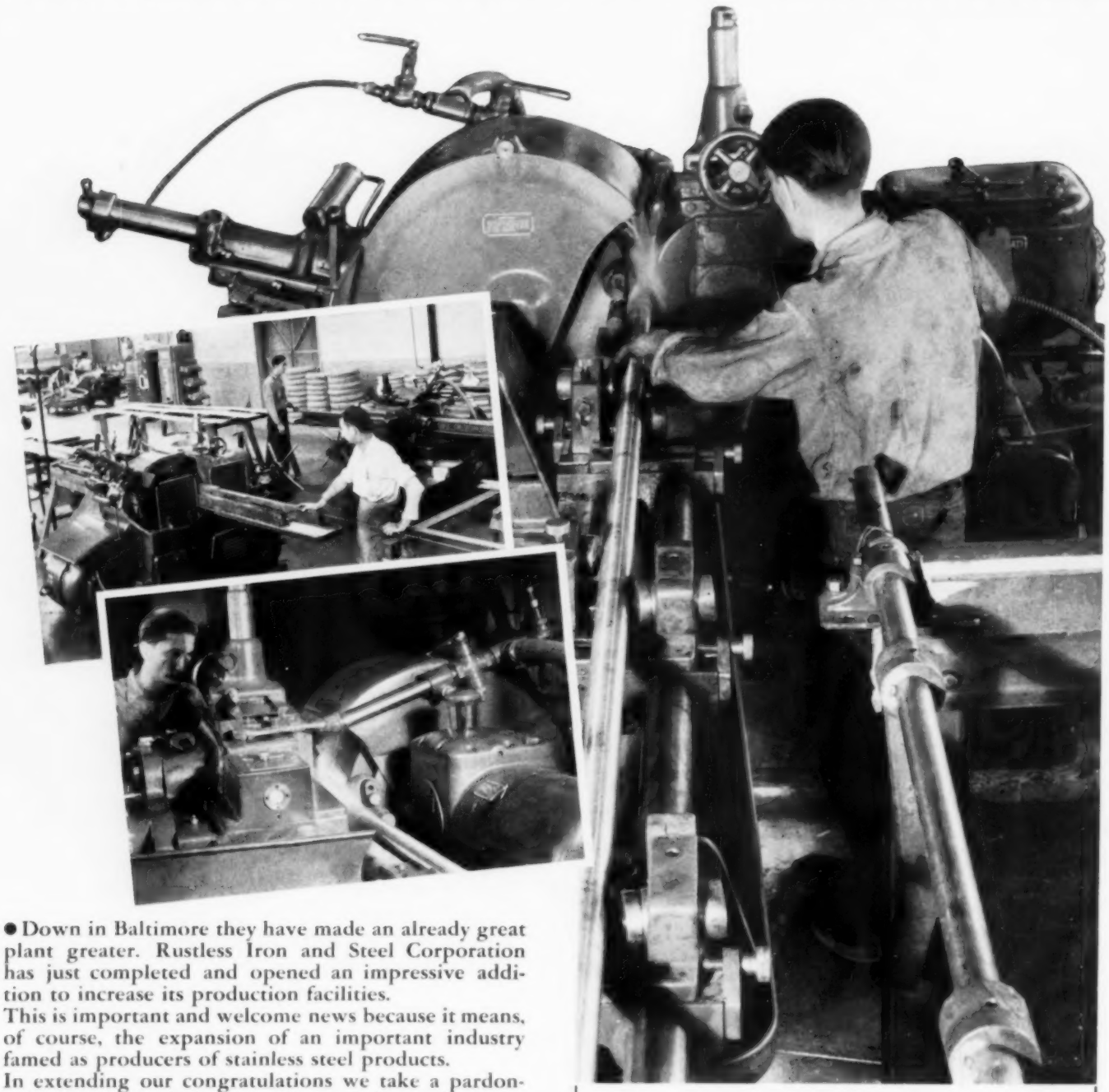
COMMERCIAL STEEL TREATING CORPORATION
DETROIT, MICHIGAN




COMMERCIAL STEEL TREATING CORP.
DETROIT

SPECIALISTS IN THE HEAT TREATMENT OF STEELS IN ALL THEIR PHASES

# CARBORUNDUM *Congratulates*
# RUSTLESS IRON AND STEEL CORPORATION



● Down in Baltimore they have made an already great plant greater. Rustless Iron and Steel Corporation has just completed and opened an impressive addition to increase its production facilities.

This is important and welcome news because it means, of course, the expansion of an important industry famed as producers of stainless steel products.

In extending our congratulations we take a pardonable pride in pointing out that grinding wheels by Carborundum are used exclusively on the battery of Cincinnati Centerless Grinders in this plant.

These wheels are being used on all production work, starting with the first or rough grinding passes and continuing right on to the production of the highly finished bar stock of all grades of stainless steel.

Once again it has been a case of providing the right wheel in the right place . . . of conscientious engineering service to the end that these wheels have become necessary and vital factors in maintaining high quality standards and high production records, and in linking the name "Carborundum" with that of "Rustless".

CARBORUNDUM
ABRASIVE PRODUCTS

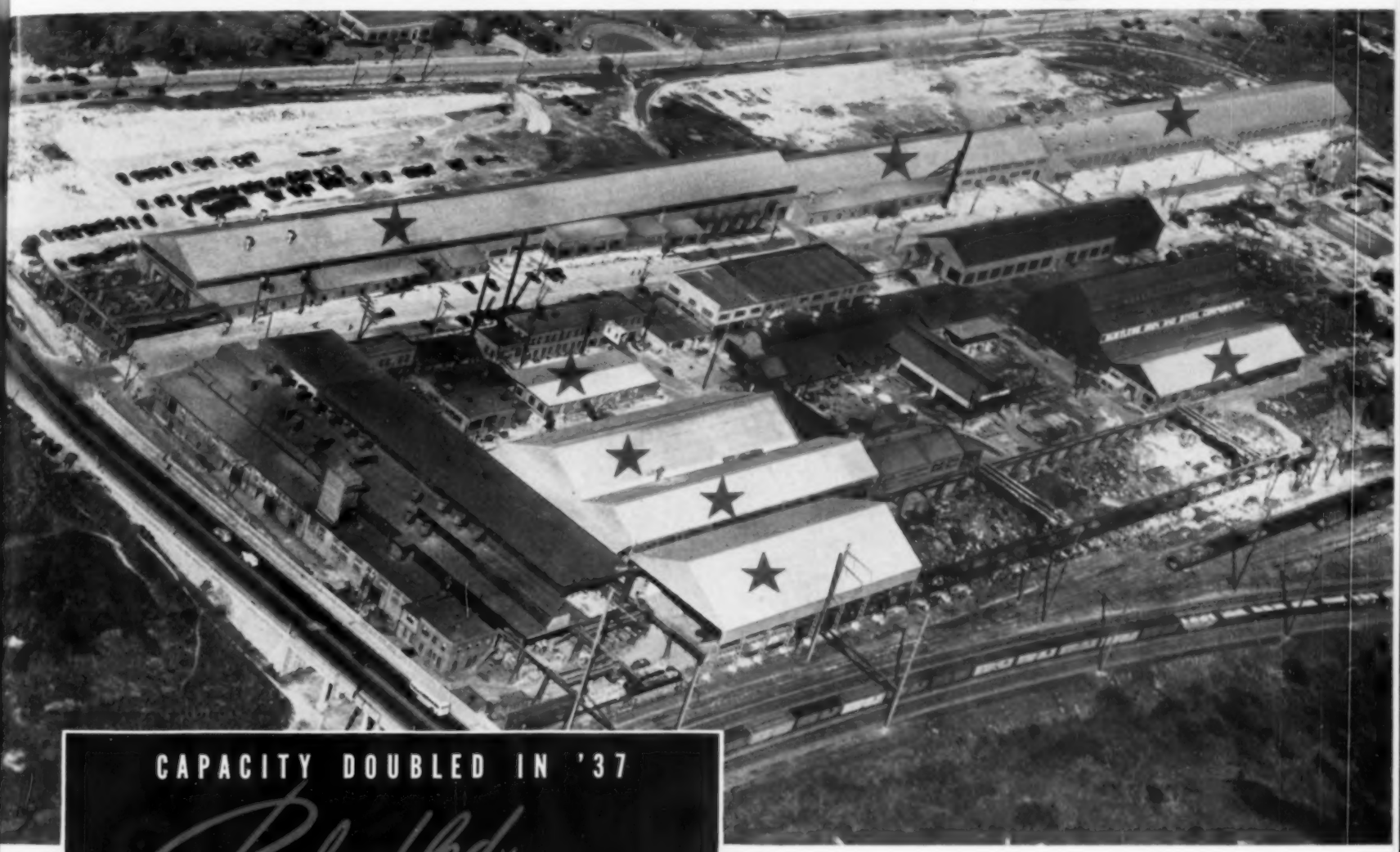
**THE CARBORUNDUM COMPANY**

*Niagara Falls, N. Y.*

Sales Offices and Warehouses in New York, Chicago, Philadelphia, Detroit, Cleveland, Boston, Pittsburgh, Cincinnati, Grand Rapids

(Carborundum is a registered trade-mark of and indicates manufacture by The Carborundum Company)

# RUSTLESS



CAPACITY DOUBLED IN '37

*Redoubled* TODAY

Compacted to a five-year period by pyramiding market demands, the "long-range" expansion program launched by Rustless in 1935 has already been completed.

Every step in the production of stainless steel bar and wire, from reduction of ore to special finishing operations, is carried on here. Straight-line production methods accelerate the movement of material, while permitting the continuous supervision and exact control that are essential. All equipment is new or completely modernized, and is specifically designed for one job and one only—the making of finer stainless steel.

The enlarged plant permits us to meet the needs of both old and new customers for increased quantities of stainless steel, while still maintaining the standards of quality and uniformity that have built our business. We will welcome the opportunity of serving you.

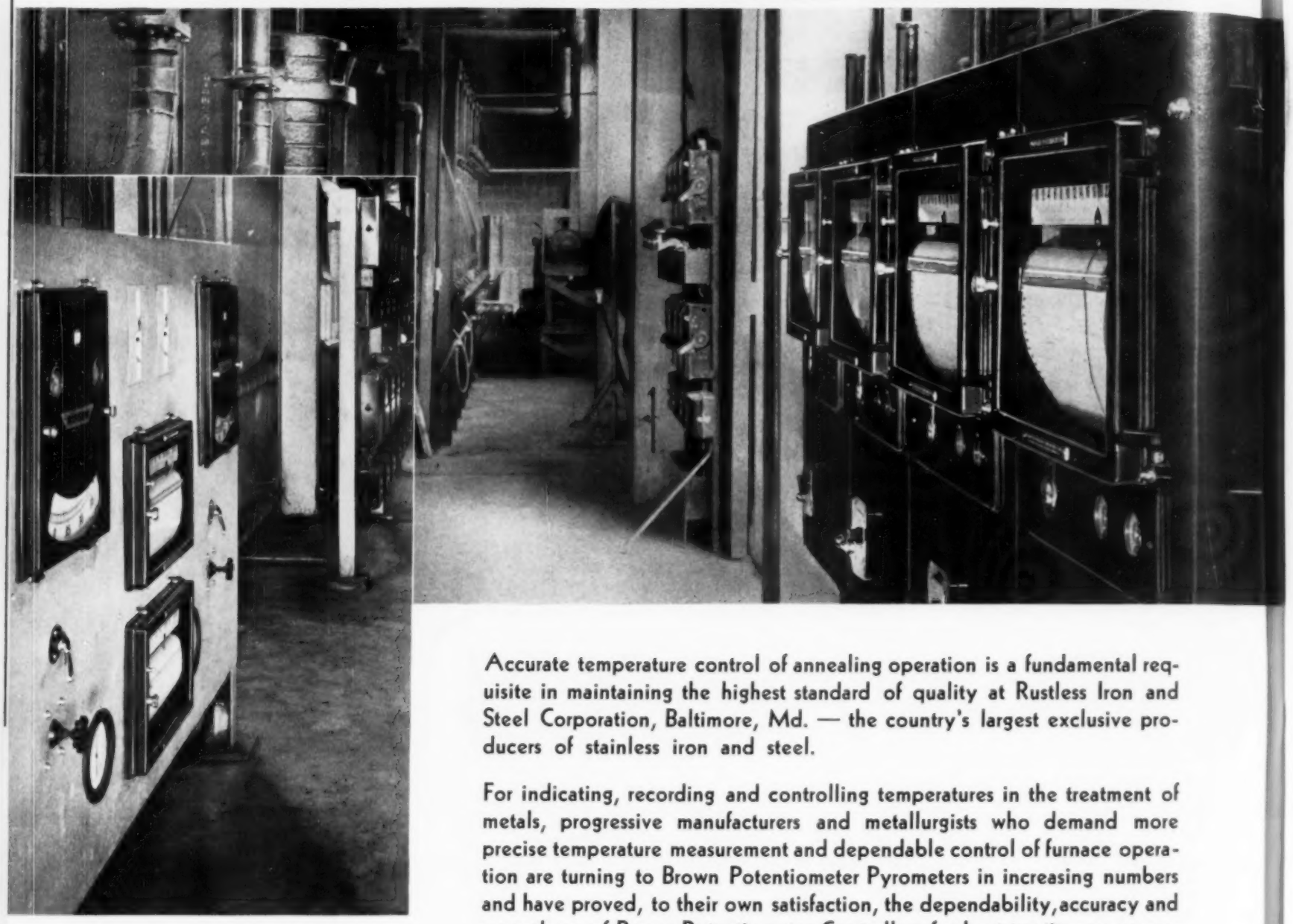
RUSTLESS IRON AND STEEL CORPORATION
BALTIMORE, MARYLAND

**RUSTLESS**
STAINLESS STEEL
BARS AND WIRE

PRODUCED BY AN ORGANIZATION
MAKING NOTHING BUT STAINLESS STEEL

SALES OFFICES: BALTIMORE · BUFFALO · CHICAGO · CINCINNATI · CLEVELAND · DETROIT · LOS ANGELES · PHILADELPHIA
DISTRIBUTORS WAREHOUSE STOCKS IN 18 CITIES

# *Guaranteeing Quality*
## IN COILED WIRE ANNEALING
## *at* RUSTLESS IRON AND STEEL CORPORATION



*The Brown Potentiometer Controllers, pictured at right, are controlling temperatures at 2000° F. of four car-type annealing furnaces designed and built by Rustless engineers.*

*The illustration at left shows Brown Potentiometer Proportioning Controllers controlling the temperature of mill ingot and mill billet furnaces.*

Accurate temperature control of annealing operation is a fundamental requisite in maintaining the highest standard of quality at Rustless Iron and Steel Corporation, Baltimore, Md. — the country's largest exclusive producers of stainless iron and steel.

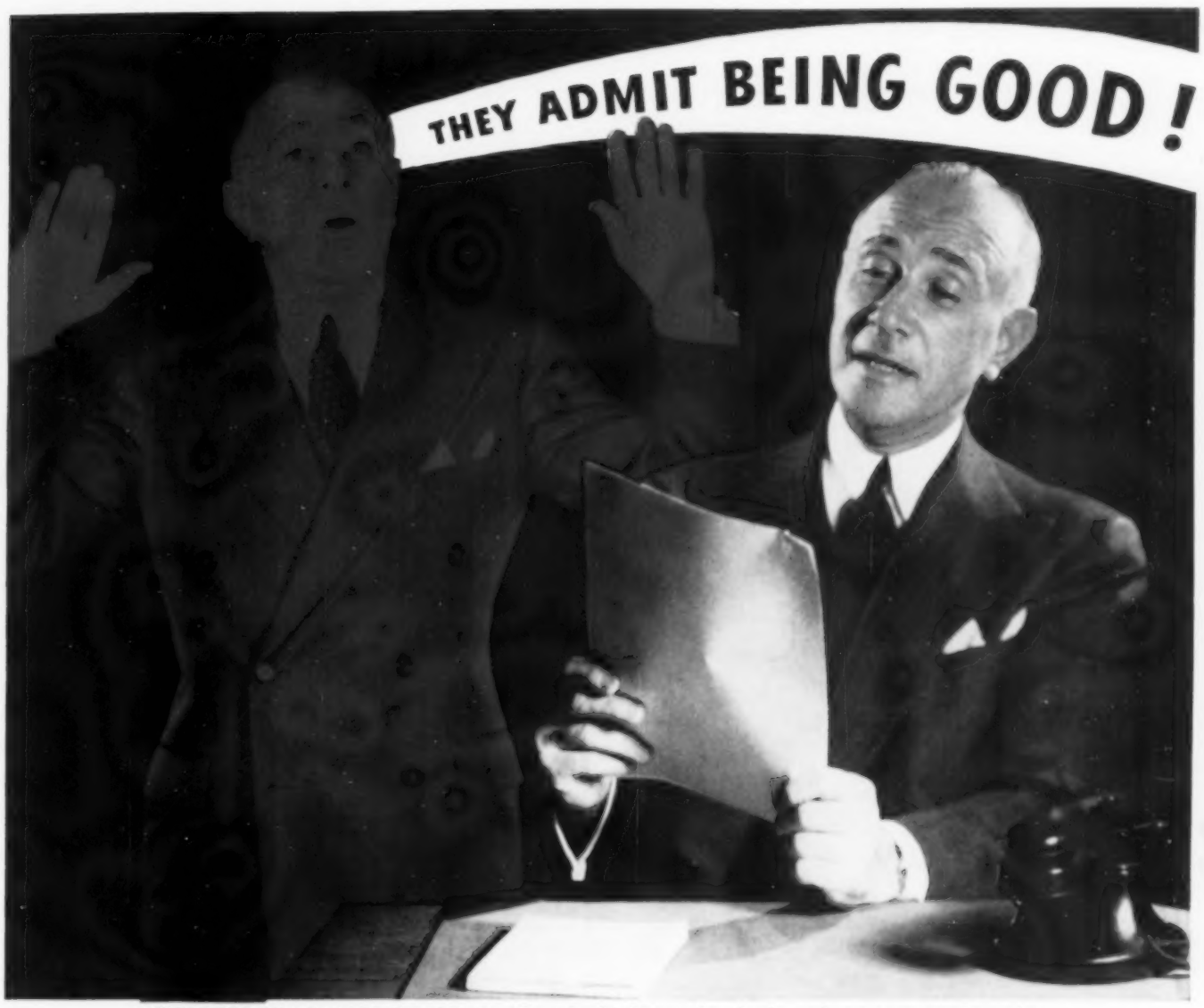
For indicating, recording and controlling temperatures in the treatment of metals, progressive manufacturers and metallurgists who demand more precise temperature measurement and dependable control of furnace operation are turning to Brown Potentiometer Pyrometers in increasing numbers and have proved, to their own satisfaction, the dependability, accuracy and ruggedness of Brown Potentiometer Controllers for heat treating processes.

When you install Brown Potentiometer Pyrometers, you can rely on their precision — be confident of their dependability.

Why not learn more about Brown Potentiometer Pyrometers — how they can aid you in simplifying heat treating processes. Catalog No. 1104 describes, in full detail, models and outstanding features of both electric and air-operated Brown Potentiometer Pyrometer Controllers. Write for a copy. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4503 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Toronto, Canada: 117 Peter Street — Amsterdam-C, Holland: Wijdesteeg 4 — England: Wadsworth Road, Perivale, Middlesex — Stockholm, Sweden: Nybrokajen 7.

# BROWN POTENTIOMETER CONTROLLERS
*and*
## MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

*To Measure and Control is to Economize*




ALTER EGO: Literally "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

**ALTER EGO:** How many have offered you a "good-as-Fleetweld" rod . . . and are they confessing or bragging?

*Well, here's the third different welding rod proposition that lays eloquent emphasis on the claim that it's* as good as "Fleetweld." *That's stimulating.*

**ALTER EGO:** No, it's emulating. Emulation admires and strives to imitate great actions. It's a human trait.

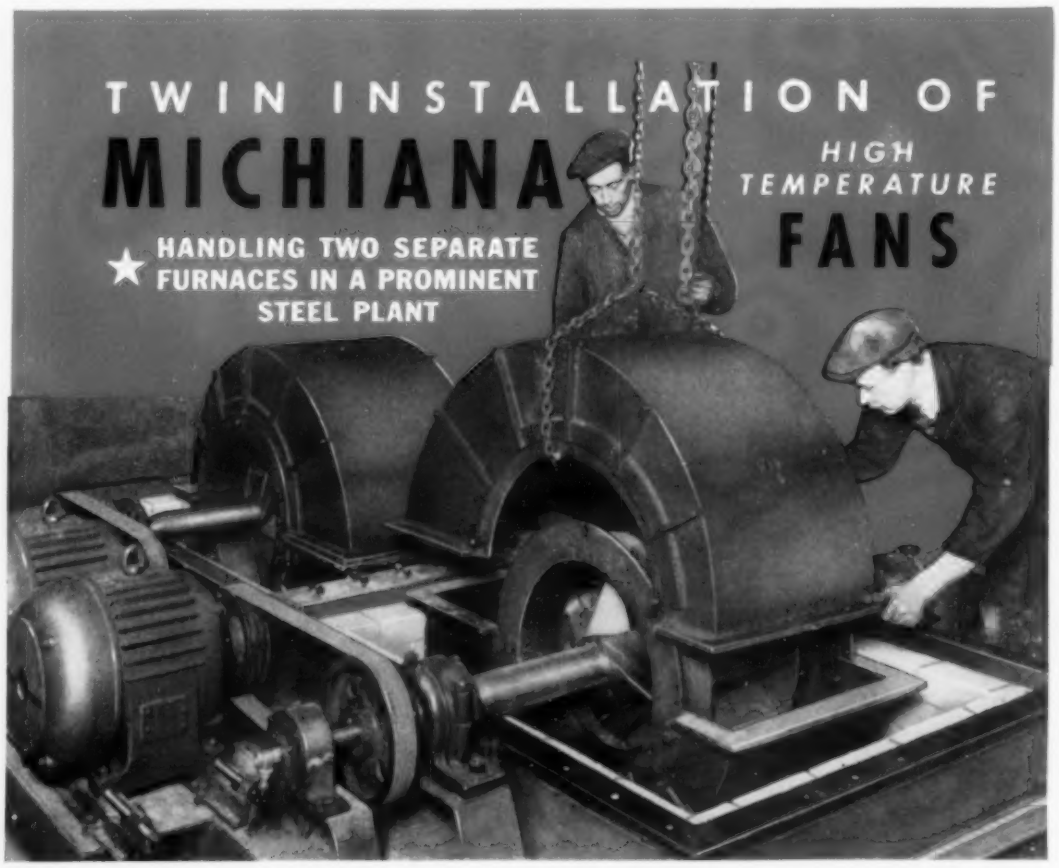
*That prompts me to ask myself—"Why is 'Fleetweld' taken as the standard of welding electrode comparison?"*

**ALTER EGO:** Maybe Lincoln can give us the FACTS and we can judge for ourselves.

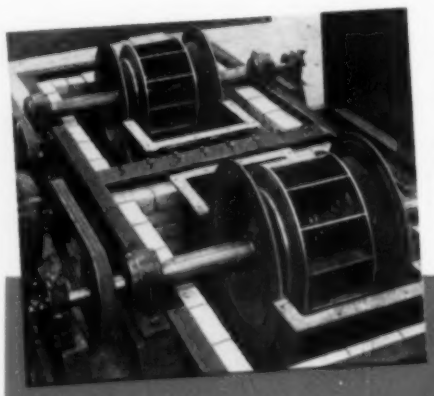
• •

LINCOLN SUGGESTS: To find out why "Fleetweld" is the standard of comparison for welding quality and economy, TRY IT! Compare it to other electrodes. In what ways? See the 30-Point Check Chart on Page 5 of the New "Weldirectory." This 56-page procedure guide (gratis) gives all the FACTS about 37 Lincoln Electrodes for welding and hard-surfacing—where to use them—how to use them—what weld properties to expect.

LINCOLN "SHIELD-ARC" WELDING
THE LINCOLN ELECTRIC COMPANY
Cleveland, Ohio
Largest Manufacturers of Arc Welding Equipment in the World




● Compactness and ease of installation are demonstrated in the application of MICHIANA FANS illustrated. ● These FANS provide controlled recirculation of high temperature gasses or products of combustion, resulting in big savings —and because of their design and construction, maintenance costs are low and costly shutdowns eliminated. THEY STAY ON THE JOB.



● MICHIANA High Temperature FANS are made of suitable heat resistant alloy, accurately machined, with the added features of NO BOLTS —SCREWS—RIVETS or WELDS, while the design and construction provide for free and independent expansion of all parts radially and axially. ● Let us help you with your problems by recommending the right High Temperature Fan for your requirements. Results are guaranteed.

**MICHIANA PRODUCTS CORPORATION**
Michigan City, Indiana

# "Nickel —PLUS RESEARCH

**with the aid of Ajax-Northrup furnaces provides alloys that are meeting industry's demand for better materials . . ."**

Says **INTERNATIONAL NICKEL COMPANY**

In the preliminary studies of new alloys of nickel in the laboratories of The International Nickel Company, Inc., small experimental melts made in coreless induction furnaces are used extensively to determine the optimum alloy ranges in the large series of closely controlled melts that must be made in the development of new alloy compositions.

Most of our modern nickel alloys were first made and are now produced in AJAX-NORTHRUP Furnaces.

At the left we show one of these furnaces of 35 KW capacity in the laboratories of the International Nickel Company. Two of these units are used at Bayonne, New Jersey, and one at Copper Cliff, Ontario, for testing and research in the ever-widening trend of nickel alloys.

**ADVANTAGES:**

Freedom from contamination from fuel or electrodes.

Oxidation and metal loss low because of speed of melt, and uniformity of heating—no hot spots.

Uniformity of melt because of natural stirring action. Electric load constant—no surging. Conditions easily maintained and duplicated. Control of temperature by power regulation. Rapid superheat or any constant temperature as desired. Quick changes in types of alloys for special orders or experimentation.

High efficiency, even with intermittent melting. Comfortable working conditions.

## Check Here ✓

### INDUCTION MELTING

**PARTIAL LIST OF APPLICATIONS**

Melting plain carbon and alloy steel, nickel, nickel-chrome alloys, magnetic alloys, etc.
Melting copper, brass and aluminum.
Melting gold, silver, platinum and other precious metals.
Melting rocks for rock wool.
Vacuum melting.
Measurement of viscosity of molten glass.
Measurement of occluded gases in metals.
Melting test samples.
Superheating cast irons.

### INDUCTION HEATING

**PARTIAL LIST OF APPLICATIONS**

Heating bars and tubes for forging and upsetting.
Heating razor blade strip for hardening.
Graphitizing carbon.
Surface hardening of interior and exterior surfaces.
Heating chemical retorts.
Heating gases for chemical processes.
Heating extrusion chambers of plastic guns.
Heating cast iron pipe for stress relieving.
Sintering powdered metals.
Heating induction motor rotors.
Heating oil well pipe joints.
Annealing sections of air drill tools.
Brazing of metal parts.
Heating dies.
Heating running boards to remove rubber.
Radio tube degassing.
Heating metallic strips.
Heating motor laminations.
Testing refractories at high temperatures.
Miscellaneous experimental applications.

AJ 33 E

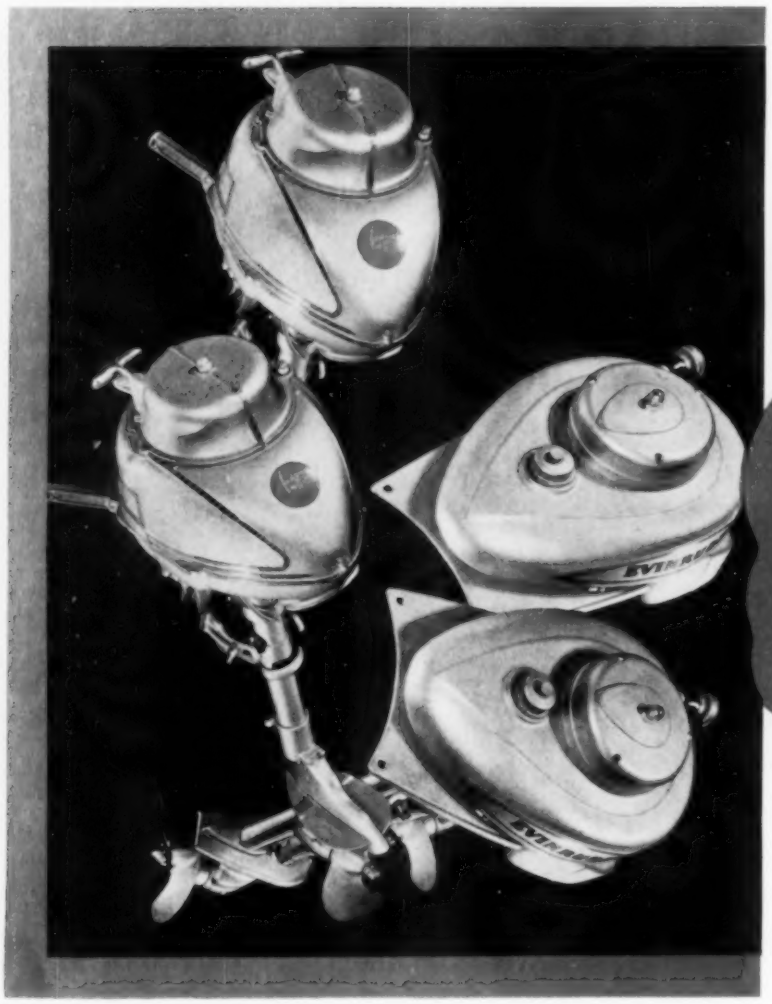
AJAX-NORTHRUP MELTING FURNACE CAPACITIES: ONE OUNCE TO EIGHT TONS

# AJAX ELECTROTHERMIC CORPORATION

**AJAX PARK · TRENTON · NEW JERSEY**

**ASSOCIATE COMPANIES**

**THE AJAX METAL CO.,** *Non-Ferrous Ingot Metal for foundry use.*
**AJAX ELECTRIC FURNACE CORPORATION,** *Ajax-Wyatt Induction Furnaces for melting.*
**AJAX ELECTRIC CO., Inc.,** *Ajax-Hultgren Salt Bath Furnace and Resistance Type Electric Furnaces.*



*Protected by*

AN

**ALROK* FINISH**

For low-cost protection of Aluminum and its alloys, consider Alrok finishes (process patented). They have proved popular for such products as outboard motors, comptometer cases, aircraft parts and gas tanks, machine parts and dental equipment. They make an excellent surface preparation for painting.

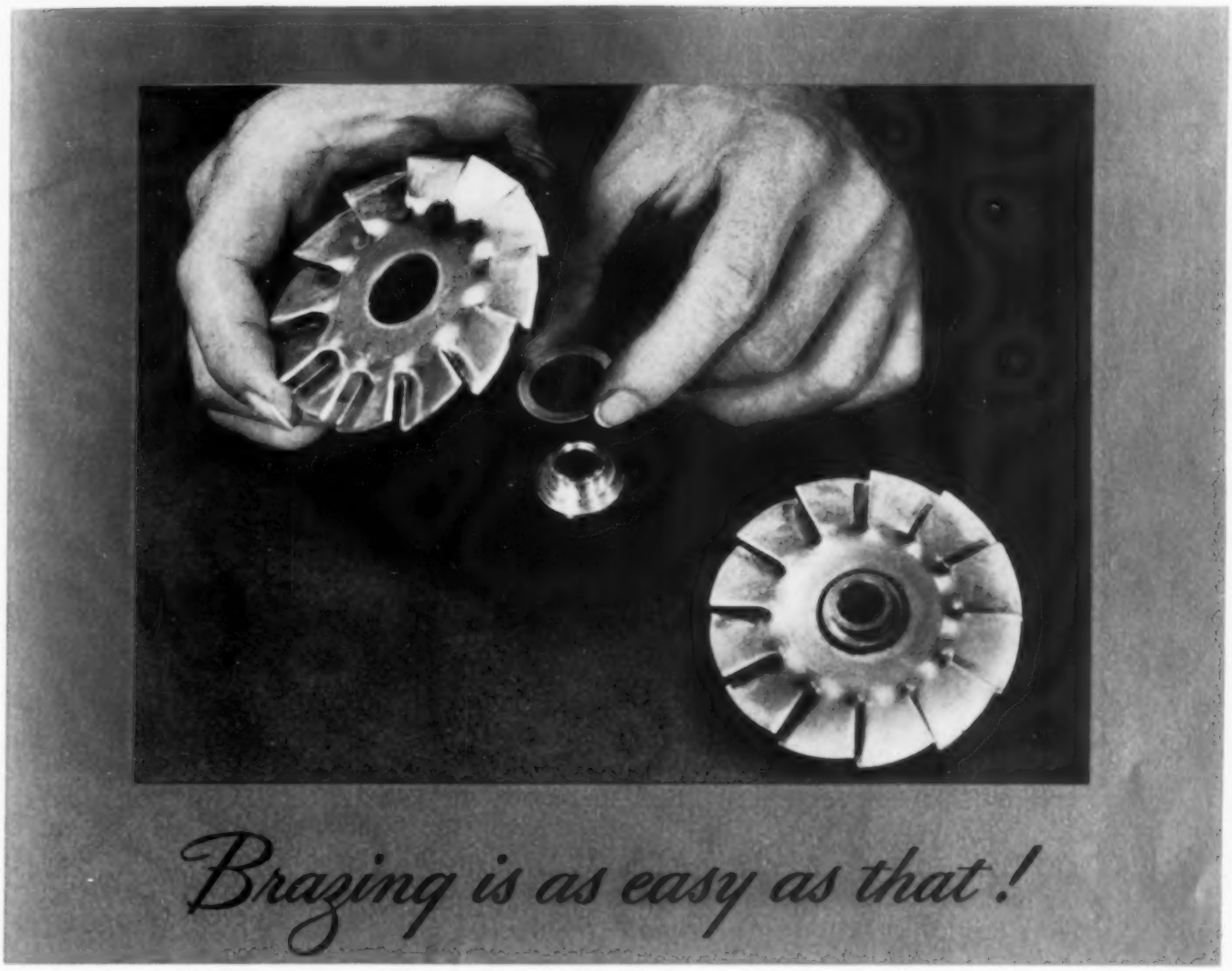
Alrok finishes are inexpensive because they are produced by chemical processes and require very little special equipment. While costing less than the harder electro-chemical finishes, Alrok finishes are decorative and provide resistance to corrosion that is satisfactory for many purposes.

The booklet, "Finishes for Aluminum", which includes information on mechanical finishing as well as electrolytic and chemical finishes, will assist in solving your Aluminum finishing problems. Send for a free copy. ALUMINUM COMPANY OF AMERICA, 2101 Gulf Building, Pittsburgh, Pa.

* Process Patented

**IT IS NEVER COSTLY TO USE ALCOA ALUMINUM RIGHT**

**ALCOA ALUMINUM**




A wipe of flux across each piece, the ring of brazing alloy between the hub and fan, then into the furnace for a few minutes; assembly of this Black & Decker portable tool ventilating fan is as simple as that!

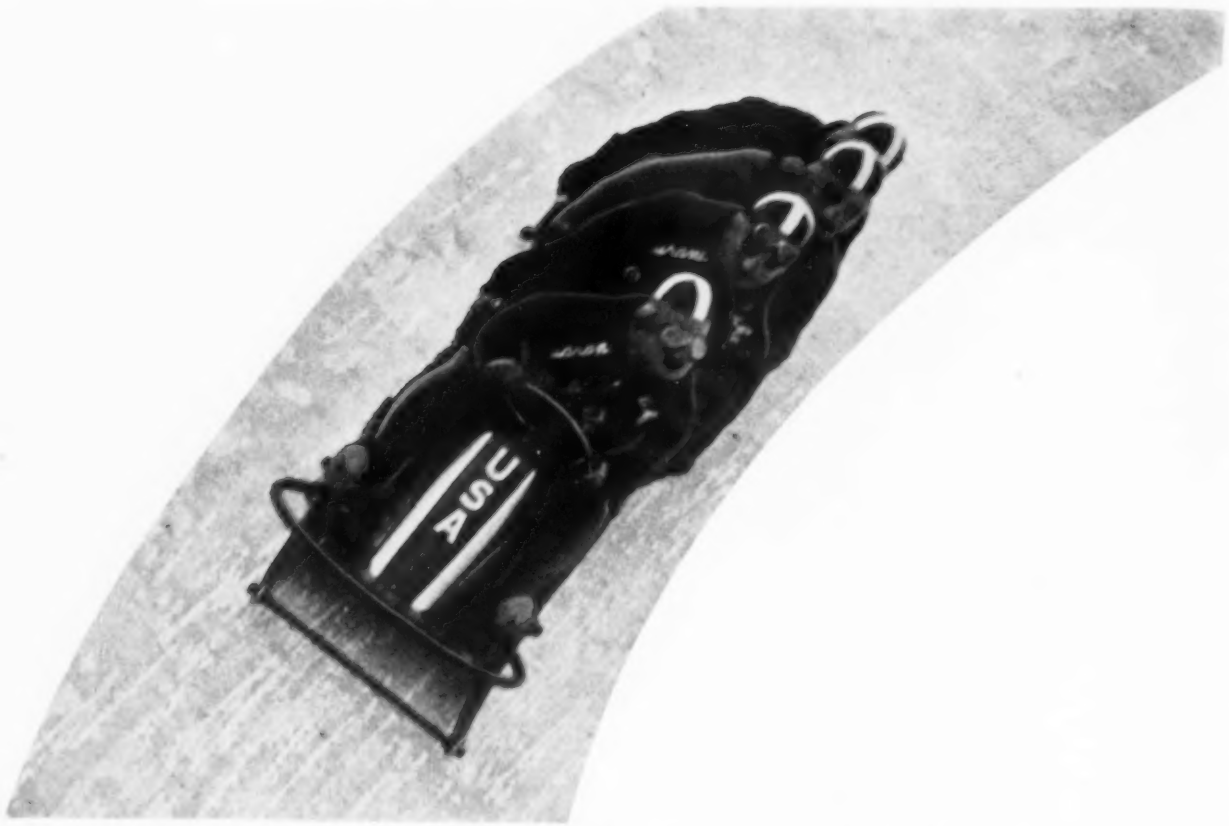
Perhaps you were one of the hundreds who saw this process demonstrated at the Metal Show in Cleveland. Marveled with the others at its simplicity. Saw it as an aid to plants pushed for production. Realized the savings possible where this process is applicable.

Did you also know that, in quenching this piece as it comes from the brazing furnace, the full strength of this Alcoa Aluminum Alloy is developed? The combination of high strength, accurate balance and a two-thirds weight reduction, obtained in this Aluminum fan, helps Black & Decker produce smoother running, longer-lived tools.

Aluminum Company of America, 2101 Gulf Building, Pittsburgh, Pennsylvania.

IT IS THRIFTY TO USE ALCOA ALUMINUM WISELY

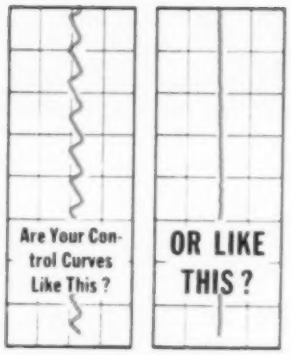
ALCOA ALUMINUM



# *STAY IN THE GROOVE . . . OR ELSE!*

**It's a perilously small groove to stay in—particularly on the turns at nearly 100 miles an hour—the slightest error in judgment by the captain—a few inches too high or too low on the glassy bank, is enough to send the bobsled hurtling off the track into the pine woods . . .**

Your heat treating furnaces need the same kind of control that the experienced captain gives his bobsled. Either they stay in the groove of straight-line temperature control or else rejections mount—and whole loads go hurtling into the annealing furnace to be rehardened—or even into the scrap heap—ruined beyond repair.




Straight line control is easy to secure with the Lindberg Throttling Control. Here is an almost-human mechanism which apportions heat in the exact quantity needed—so that temperatures stay right in the groove with the happy result that rejections due to over or underheating are eliminated. Any furnace manufacturer will give you details—or write Lindberg Engineering Co., 222 North Laflin Street, Chicago.

## LINDBERG *Throttling* CONTROL

## *Testing Control*

### Comparator-Densitometer

A unit for accurately and speedily projecting a spectrogram on a viewing screen and enabling positive spectral lines identification up to 70 elements is covered by a new folder released by Harry W. Dietert Co. Bulletin Kd-198.

### Rockwell Tester

A revised and completely up-to-date catalog on the well-known Rockwell hardness tester is well illustrated and contains 24 pages. Published by Wilson Mechanical Instrument Co., Inc. Bulletin Ca-22.

### High-Speed Recording Pyrometer

The Speedomax Recorder, a high-speed instrument for recording temperatures of moving objects such as billets, slabs, rails, etc., is described in a 12-page bulletin issued by Leeds & Northrup Company.

For a copy of this publication, write for Bulletin Nd-46.

### Metallographic Equipment

The 100-page "Metal Analyst" issued by Adolph I. Buehler features new Metallographic Sample Preparation Equipment; a comparative listing of Metal Microscopes, Measuring Microscopes, and Spectrographs; an index of over 1,000 new technical books and papers; and a treatise on the Application of Reflected Light. Bulletin Ed-135.

### Strain Gage

Baldwin Southwark has just issued an attractive booklet describing the SR-4 Bonded Metalectric strain gage. This gage presents a revolutionary method for determining stresses in structures under conditions which have been difficult heretofore. Bulletin Kd-67.

### Recorder-Controllers

Foxboro's new booklet describes the permanent precision, low maintenance and reductions in spare-parts inventories for Potentiometer Recorders and Recorder-Controllers. Bulletin Kd-21.

### Preventive Insurance

Protection against the losses caused by excessive temperatures is guaranteed by the Limitrol, a new Wheelco development for automatic temperature control. Fully described in this new booklet. Bulletin Ld-110.

### Optical Strain Gauge

The Tuckerman Optical Strain Gauge for measuring tension and compression strains as small as 0.000002 inch in various materials, structural parts and structures is described more completely than ever before in a bulletin made available by the American Instrument Co. Bulletin Nd-259.

### Pyrometer Controllers

A new catalog by the Brown Instrument Co. describes, in full detail, models and outstanding features of both electric and air-operated Brown Potentiometer Pyrometer Controllers. Bulletin Nd-3.

### Bristol Potentiometers

All of the Pyromaster Round-Chart Potentiometers manufactured by the Bristol Company are described in a new bulletin which explains the simple operating characteristics of Bristol's Pyromaster. Bulletin Nb-87.

## *Steel Iron*

### Recommended Tool Steels

A new chart giving the brands of Jessop tool steels recommended for various tools, dies and other applications, has just been released by the Jessop Steel Co. Bulletin Ic-173.

### N-A-X

New twenty-page, fully illustrated booklet on N-A-X high tensile low alloy steel has just been published by Great Lakes Steel Corporation. This steel has been thoroughly proved in application where ordinary high tensile steels have failed. Bulletin Kd-229.

### Special Steels

An impressive new 160-page Hand Book of Special Steels which gives the very latest data on the characteristics and applications of Allegheny Ludlum tool steels has just been printed. Write today since issue is limited. Bulletin Ic-92.

### Machine Tool Castings

A completely illustrated 16-page booklet containing applications of Meehanite castings in the machine tool industry has been prepared by the Meehanite Research Institute of America, Inc. Bulletin Kd-165.

### Free Machining Steels

Speed Case and Speed Treat, two steels with increased machining properties, are described in literature available through Monarch Steel Co. Bulletin Cd-255.

### Steel Data Sheets

Wheelock, Lovejoy & Co. gives analyses, physical properties, heat treating instructions, and applications of Hy-Ten, Economo, and S.A.E. alloy steels in concise and easily usable form. Bulletin Ox-74.

### High Speed Steel

Required hardness and extraordinary toughness combine to make Firth-Sterling Steel Co. new high speed Steel "Mo-Chip" of unusual interest to manufacturers who need a steel that is "practically indestructible." Bulletin Ad-177.

### Graphitic Steel

A new 16-page booklet showing 24 specific Graphitic Steel Applications for increasing tool speed and reducing replacements is just off the press — available through The Timken Roller Bearing Co. Bulletin Nd-71.

### Permanent Magnet Steels

A booklet issued by the Simonds Saw & Steel Co. on "Permanent Magnet Steels and Castings" is now available. Bulletin Kc-158.

### Durodi

Durodi . . . "The practical, serviceable and economical hot work steel" . . . is described in a catalog issued by A. Finkl & Sons Co. Points out uses and characteristics of this alloy. Bulletin Ib-23.

### General Data Book

Valuable reference and data are contained in a book by Joseph T. Ryerson & Son, Inc., which gives metallurgical definitions, heat, hardness, and numerical equivalent tables as well as many valuable operating facts. Bulletin Nc-106.

### Rustless Handbook

Offered as an answer to the question, "Which stainless steel?" a 60-page handbook by Rustless Iron and Steel Corp. gives complete information on properties, processing, and engineering applications of a wide variety of rustless and stainless steels. Excellently arranged and printed. Bulletin Bb-169.

### Petroleum Stainless

A fully illustrated 52-page, 8½x11" wire bound handbook, covering U.S.S. Stainless and Heat Resisting Steels for the Petroleum Industry, has just been made available by the United States Steel Corp. Bulletin Hd-79.

### Welded Stainless Tubes

A really striking 16-page booklet containing 45 illustrations on Welded Stainless Tubing is offered by the Carpenter Steel Co. Bulletin Kd-12.

### "Aircraft Quality" Steels

The line of steels and steel products manufactured by Republic Steel Corporation is so diversified that the company has prepared a complete listing which is now available in one booklet. Bulletin Ic-8.

### Die Steels

For applications where toughness and the ability to withstand wear is essential, the G.S.N. Die Steels described in Latrobe Electric Steel Company's new booklet fill the bill. Bulletin Ld-208.

### 8-Steel Tool Kit

A compact set of 8 shop-proved tool steels that will handle 90 per cent of the jobs in any plant are outlined by The Bethlehem Steel Co. Bulletin Hd-76.

### Moly in Steel

Metallurgists, engineers and production executives who are really interested in the metallurgy of steels and their application will want the excellent book on molybdenum steels published by Climax Molybdenum Company. Bound in loose-leaf manner, this reference book is chock-full of tables which form a volume almost an inch thick. Bulletin Hb-4.

### Phosphorus-Iron Alloys

Abstracts of U. S. Patents relating to phosphorus as an alloying element in steel and list of iron and steel patents is included in a big book just released by Monsanto Chemicals Co. Bulletin Kd-272.

## *Furnaces Industrial Ovens Refractories*

### Industrial Furnaces

Furnaces of all types are fully described in technical bulletins made available by the Eclipse Fuel Engineering Co. Bulletin Hc-226.

*More literature listed on following page*

# HELPFUL

## Metal Heating

Improvements in furnace economies, operating conditions and appearance, furnaces that will more satisfactorily meet old requirements or handle new processes, service that will help solve the most stubborn problems are offered and described by Mahr Mfg. Co. in Bulletin Ea-5.

## Model "Y"

The Sentry Model "Y" electric furnace, using the Sentry Diamond Block method of heat treatment, provides exceptional quality high speed steel hardening at minimum production cost. The furnace is described in Bulletin Oy-114.

## Clean Hardening

Continuous clean hardening machines for work ranging from extremely small, light springs, stamping, drop forgings, etc., up to quite large and heavy pieces are described in a bulletin by the American Gas Furnace Co. Bulletin Ed-11.

## Oil Burners

North American Mfg. Co. offers a bulletin describing improved low pressure oil burners, one type especially designed for automatic control and ideally suited for use with proportioning control valves. Bulletin Na-138.

## Bright Annealing

Various types of electric and fuel-fired furnaces built by the Electric Furnace Co. for bright-annealing wire, tubing, strip and other products are described in an 8-page folder. Bulletin Lb-30.

## Electric Furnaces

A new catalog on electric furnaces and pyrometers has been released by the Hoskins Manufacturing Company. For anyone who does any kind of heat-treating, brazing or uses heat-resisting castings. Bulletin Hc-24.

## Vap-O-Gas

Vapofier Corporation equipment offers the only complete, instantly usable stand-by safeguard available for use with fuel oil or gas through the same burners and manifolding. If you have heat treating equipment in your plant investigate the advantages of economy and efficiency of Vapofier. Bulletin Kd-290.

## Portable Electric Furnace

A unique portable electric furnace designed for use at temperatures below 1100° F. with drawing salts and oil tempering baths is described in a booklet by Claud S. Gordon Co. Bulletin Ed-53.

## Hardening Furnace

A new radiant tube vertical-type hardening furnace for hardening drop forged mechanics' tools without scale or decarburization is described and shown in Surface Combustion's new folder. Bulletin Kd-51.

## Heroult Furnace

Revised and expanded to include modern major innovations in the construction and operation of the Heroult electric furnace, the latest edition of the American Bridge Co.'s Heroult Electric Furnace Bulletin is available. Bulletin Bb-124.

## Handling Heat

Alundum and Crystolon refractories meet all requirements for kiln linings and kiln furniture. An attractively laid out and illustrated folder gives the evidence. Norton Co. Bulletin Bb-88.

## Turbo-Compressors

Spencer Turbine Co. has turbo-compressors in all sizes and types for oil and gas-fired furnaces, ovens and foundry cupolas. Special types for special purposes such as gas-tight and corrosion resisting applications are also described in Bulletin Da-70.

## Super Refractories

A very handsome spiral-bound 76-page catalog covering their extensive line of refractories for heavy duty service is offered by the Carborundum Co. Bulletin Ld-57.

## Electric Carburizer

Interesting features of their electric carburizer available in mass production quantities are contained in a colorful 20-page booklet just released by Hevi Duty Electric Co. Bulletin Ld-44.

## Insulation

A 32-page catalog containing specific information on all of the sheet, block and pipe insulations developed by the Johns-Manville Company is now available through that company. Bulletin Fb-100.

## Aircraft Heat Treating

A special bulletin "Heat Treating Furnaces for the Aircraft Industry" has just been prepared by the Lindberg Engineering Co. Bulletin Nd-66.

## Salt Bath Furnace

New 20-page Catalog describing the Ajax-Hultgren Electric Salt Bath Furnace. Gives detailed data on all heat treating applications such as carburizing, cyanide hardening, hardening carbon and high speed steel tools without scale or decarb, heat treating aluminum alloys, tempering steel products, heating for forging, brazing, etc. Bulletin Nd-43.

## New Furnace Bulletin

Many ideas to help solve your furnace problems are contained in a new booklet by the Despatch Oven Co. Bulletin Nd-123.

## Gas-Carburizing Furnace

A new gas-carburizing, electric furnace which makes possible remarkable savings in time and power cost is explained in a booklet released by the General Electric Co. Bulletin Nd-60.

## Globar Elements

Globar Pin Type Non-Metallic Electric Heating Elements and Terminal Rods and Globar "AT" Type Non-Metallic Electric Heating Elements are explained and illustrated in two booklets issued by the Globar Division of the Carborundum Company. Bulletin Lb-25.

## Industrial Compressors

Small industrial compressors and vacuum pumps, from ¾ to 15 h.p., are covered in a bulletin which gives complete rating tables of more than 50 models. Ingersoll-Rand Co. Bulletin Ec-222.

## New Electric Furnace

An electric furnace that is new in every respect . . . including new insulating refractory lining, increased wall insulation, simplified door lift mechanism . . . is described in a bulletin released by the American Electric Furnace Co. Bulletin Gd-2.

## Electric Furnaces

Economy . . . ruggedness . . . speed . . . and versatility distinguish the line of electric furnaces described in a new bulletin by The Detroit Electric Furnace Division, Kuhlman Electric Co. Bulletin Hd-271.

## Electric Furnaces

A four-page bulletin on ⅛ lb. to 4 lb. high frequency melting furnaces and 3 kw. converter is now available through the Ajax Electrothermic Corp. Bulletin Dd-41.

## Furnace Experience

Facts developed through 32 years of engineering and building practically every type of industrial fuel equipment can be obtained through Flinn & Dreffein Co. Bulletin Bc-82.

## Lectromelt Furnaces

The story behind lectromelt furnaces is well told in this 48-page booklet issued by the Pittsburgh Lectromelt Furnace Corporation. Tells of development and recent improvements. Bulletin Db-18.

# *Finishing • Plating • Cleaning*

## New Cleaning Methods

Illustrated new 32-page Booklet issued by Oakite Products, Inc. describes formulas, methods for safely cleaning aluminum, magnesium, zinc die castings and other metals and alloys before electroplating, cleaning polished steel, brass, copper. Also includes data on tumbling, burnishing, pickling. Bulletin Nd-296.

## Cadmium Plating

Concise, practical information for the operating plater is included in an up-to-date manual on cadmium plating released by E. I. DuPont de Nemours & Co., Inc. Bulletin Hd-29.

## Rotoblast

Quicker production Blast Cleaning Equipment for producers of metal castings, forgings and heat treated parts is explained in literature just released by the Pangborn Corp. Bulletin Ic-68.

## Mounted Wheel Chart

A convenient ready reference wall chart showing mounted grinding wheels should be of great advantage in the cleaning room, pattern shop, tool and die room, and many other places. It gives at a glance, by means of detailed drawings, actual size, the exact radius of each wheel and its exact shape. Chicago Wheel & Mfg. Co. Bulletin Bd-230.

## Metal Descaling

A process which overcomes past descaling disadvantages through a new method which removes scale completely without the slightest damage to the work is introduced in a folder by the Bullard-Dunn Process Division of the Bullard Co. Bulletin Ld-143.

## Aluminum Finishes

Good printing, good paper, spiral binding and an attractive presentation add interest to the valuable technical information on "Finishes for Aluminum" contained in Aluminum Co. of America's new booklet. Bulletin Oy-54.

## Degreasers

An interesting line of portable degreasers which can be taken to the work—instead of bringing work to the degreaser—is shown and described in a colorful folder by the Phillips Manufacturing Co. Bulletin Nc-254.

# *Heat Treatment*

## Flame Hardening

"Flame Hardening Apparatus", a new 12-page bulletin issued by the Air Reduction Co., makes available details and apparatus involved in flame hardening surfaces of various forms. Bulletin Kd-69.

## Induction Heating Equipment

High frequency induction heating equipment for rapid, accurately controlled localized heating, melting, brazing is covered by folders released through Ecco High Frequency Corp. Bulletin Kd-281.

# LITERATURE

### Heat Treat Chart

Heat treaters everywhere should find a heat treating wall chart complete with S.A.E. specifications a very valuable addition to their shops. Published by Chicago Flexible Shaft Co., manufacturers of Stewart industrial furnaces. Bulletin Ka-49.

### Tocco Process

The marvel of all heat treaters—the Tocco Process of Induction Hardening—is fully described in a colorful folder by the Ohio Crankshaft Co. Bulletin Lc-145.

### Houghton Products

A colorful 24-page booklet "Houghton Products for the Metal-Working Industries" summarizes the leading developments of Houghton Research which contribute to metallurgical progress. Interesting and valuable, this booklet will be helpful to any metal man. E. F. Houghton & Co. Bulletin Nd-38.

### Temperature Determination

A new device for determining temperatures in industry, consisting of little thermometric pellets called "Tempils" is explained and illustrated in an attractive folder printed by the Tempil Corp. Bulletin Fd-270.

### High Temperature Fans

A 4-page illustrated bulletin on this subject has just been released by Michiana Products Corp. The applications (where temperature requirements range up to 1800° F.) are enumerated and construction described. Stock sizes mentioned include fans up to 32,000 cubic feet per minute capacity. Bulletin Hb-81.

## *Heat Resistant Metals*

### Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

### X-Ray Inspected Castings

All types of heat and corrosion resistant castings made with extensive use of "X-Ray Inspection" and modern foundry methods are shown and described in a 16-page two-color booklet made available by the Electro-Alloys Co. Bulletin Ld-32.

### High Temperature

High temperature uses of Monel, Nickel and Inconel are analyzed and pictured in a recently printed bulletin released by International Nickel Co. Bulletin Kd-45.

### Heat Resisting Castings

A 4-page folder on Pyrasteel heat resisting castings, that shows applications of special alloy steels and their analyses, also information on welding alloy steels, is available through Chicago Steel Foundry Co. Bulletin Cb-184.

## *Welding • Cutting*

### Contour Machining

A new Handbook on Contour Machining containing 158 pages of valuable metal working helps is being made available by Continental Machines, Inc. Bulletin Nd-170.

### Weldirectory

An impressive 56-page directory covering the procedure and selection of welding supplies and equipment has been issued by the Lincoln Electric Co. Extremely helpful to anyone with a welding problem. Bulletin Nd-10.

### Metal Welding

Of particular interest to the aircraft industry and all fabricators of light-gauge metal will be the booklet "Sheet Metal Welding Fundamentals" released by the Linde Air Products Co. Bulletin Ed-63.

### Welding Stainless

How to weld stainless steels is described in a colorful 12-page folder released by the Page Steel and Wire Division of American Chain & Cable Co., Inc. Bulletin Cc-86.

## *Non-Ferrous Metals*

### Copper Bulletin

A new clearing house for news of developments in brass, bronze and copper, the "Copper Alloy Bulletin", issued by the Bridgeport Brass Co., made its appearance with the March issue. It is edited for the technical and engineering audience. Bulletin Da-163.

### Vital Points

The ability of Ampco Metal to safeguard the vital points in industry's outstanding mechanical equipment is described in "Brief Facts About Ampco Metal", a 16-page illustrated booklet just issued by Ampco Metal, Inc. Bulletin Ld-175.

### Dowmetal Data Book

A new edition, containing especially significant accomplishments in the sections of "Available Forms" and "Shop Practice" has been published by Dow Chemical Co., Dowmetal Div. Bulletin Ec-215.

## *Metal Working • Forging*

### Cutting Alloy

New price sheets released by the Carboloy Company will be interesting to men concerned with machining problems. Bulletin Kd-278.

### Shear Knife

A handbook describing the development of the solid steel shear knife by Sam Heppenstall, founder of the Heppenstall Company. Compact, bound in imitation leather, this booklet contains valuable data in the form of hardness conversion table and shear knife performance charts. Bulletin Db-122.

### Hard Facing Alloys

For maximum resistance to wear and corrosion, the Wall-Colmonoy Corp. offers a fact-packed folder which is extremely helpful to anyone having this problem. Bulletin Kd-85.

### Cutting Oil

An informative booklet containing 48 pages of scientific applications for the largest selling sulphurized cutting oil is offered by D. A. Stuart Oil Co., Ltd. Bulletin Kd-118.

### Cutting Oils

An interesting new booklet, "Metal Cutting Lubrication — In Theory and Practice", has just been made available by Cities Service Oil Co. Bulletin Ec-113.

## *Melting • Casting*

### Ingot Production

"The Ingot Phase of Steel Production" is the title of a book defining the principles of quality ingot production followed by many well-known steel manufacturers. Gathmann Engineering Co. Bulletin Ka-13.

### Foundry Sand

A pamphlet recently issued on TAM Foundry Zircon Sand and TAM Zircon Flour contains detailed information on these products of the Titanium Alloy Mfg. Co. Bulletin Hc-90.

### Pit Handbook

A virtual handbook on soaking pit procedure best describes the new booklet published by Amsler-Morton Company. Included are comprehensive case histories of pits now in successful operation. Bulletin Kd-286.

### Ferro-Alloys

An interesting folder by Electro Metallurgical Co. tells all about their ferro-alloys and their special service to users which will help them to operate their furnaces and make alloy additions under the proper conditions. Bulletin Jy-16.

### Pure Metals

Pure, carbide-free metals are described and applications suggested in a pamphlet published by Metal & Thermit Corp., who make pure tungsten, chromium and manganese in addition to the ferro-alloys. Bulletin Ma-64.

Metal Progress, 7301 Euclid Avenue, Cleveland, O.
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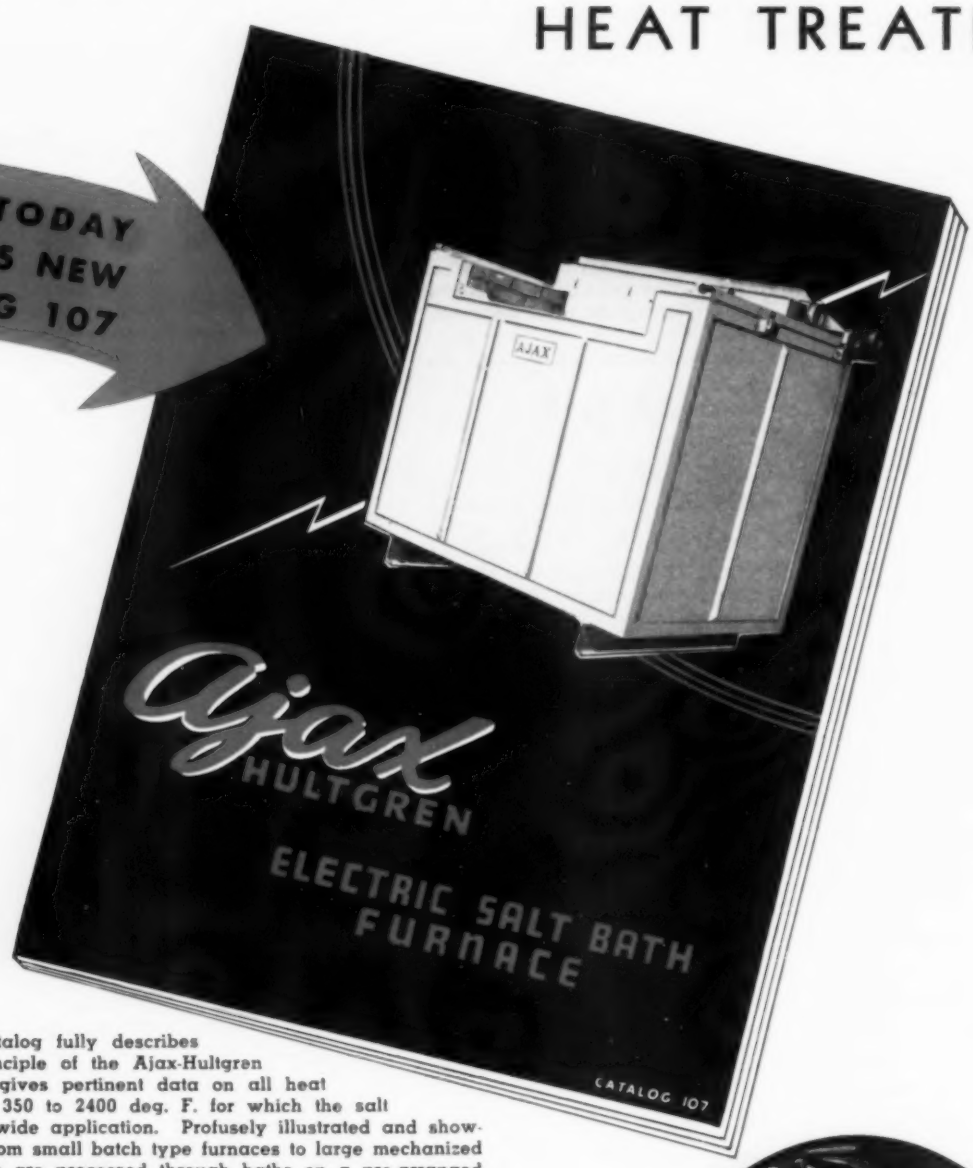


This newest 20-page catalog fully describes the internal heating principle of the Ajax-Hultgren Salt Bath Furnace and gives pertinent data on all heat treating operations from 350 to 2400 deg. F. for which the salt bath method has found wide application. Profusely illustrated and showing actual installations from small batch type furnaces to large mechanized units, in which the parts are processed through baths on a pre-arranged time cycle, by means of fully automatic conveyors.

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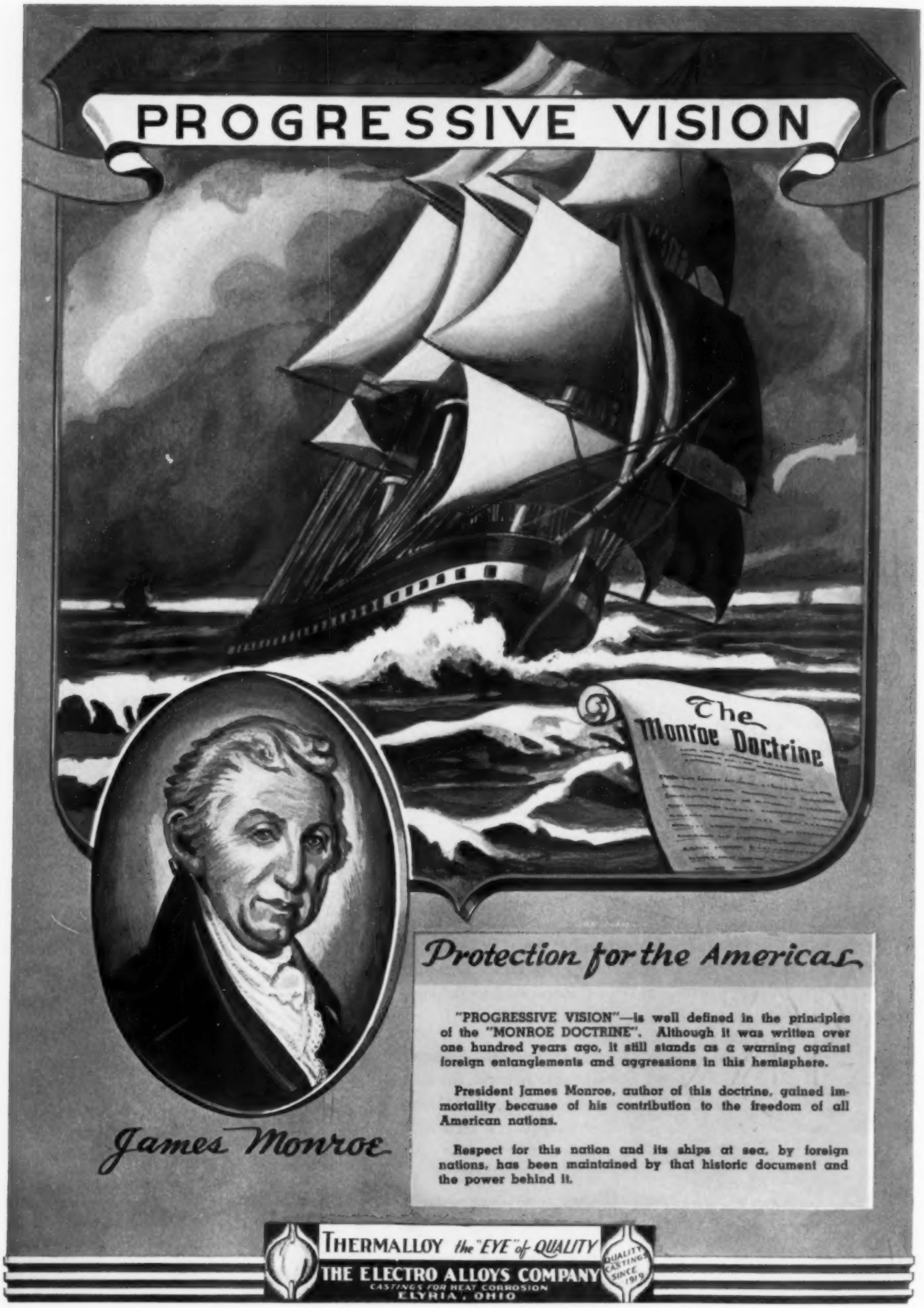
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DECEMBER, 1940

# COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

*Prepared Each Month by the Bridgeport Brass Co.* "Bridgeport" BRASS CO. *Headquarters for BRASS, BRONZE and COPPER*

## Range Switch Parts Complete More Than Six Million Cycles

Striking proof of the superior spring quality of Bridgeport's phosphor bronze is given by the results of life tests on the switch control for electric ranges illustrated in the accompanying photograph. All spring parts in this switch are fabricated from phosphor bronze supplied by Bridgeport.

The switch was tested for a period of more than six months, and 6,408,000 cycles were completed without any sign of failure in the switch parts. Bridgeport's up-to-the-minute rolling mill facilities and careful laboratory control of processing are outstanding factors in establishing this exceptional performance record for phosphor bronze. Fabricators of spring parts for electrical or mechanical equipment can give their products greater life expectancy and the ability to withstand severe service by utilizing the superior toughness and resilience of Bridgeport Phosphor Bronze.

*Tuttle and Kift*

## Low-Melting Alloy Used As Tube-Bending Filler

Thin-walled tubes of copper or brass can be bent successfully and without rippling by filling the tubes with Cerrobend, a low-melting alloy of bismuth, lead, tin, and cadmium, it is claimed. Cerrobend is said to be free from many of the disadvantages that have characterized previously employed filling materials. When substances such as resin, pitch, or sand are employed, it is said to be difficult to remove all traces of the filler from the inside of the tube after the bending operation is completed. Cerrobend, however, can be successfully removed, it is said, and tests are reported to prove that no alloying takes place between Cerrobend and the metal of the tube.

Cerrobend melts at about 160° F., and is said to have the unusual property of expanding instead of contracting as it cools. For this reason, it conforms closely to the interior of the tube, which can be bent much like a solid bar, it is reported. It can, of course, be used over and over again, so that costs are low.

## Copper and Copper Alloys Vital In Carrying Out Defense Program

### *Unique Combination of Strength, Toughness, Ductility And Corrosion Resistance Accounts for Their Wide Use*

Copper and its alloys are playing an essential role in the progress of the current defense program, particularly in the manufacture of ammunition. Strength, toughness, freedom from brittleness, and the ability to withstand sudden severe shocks which would destroy ordinary materials are important factors in the use of the copper alloys. They are exceptionally ductile and easy to fabricate rapidly. Moreover, they have high resistance to the effects of corrosion and weathering, and can therefore be stored for long periods of time without deterioration.

### *Memos on Brass—No. 16*

Common High Brass, having a nominal composition of 66% copper and 34% zinc, is the most widely used copper alloy for general fabricating purposes. Its popularity is the result of the balance it achieves between initial cost and ease of fabrication. Copper-zinc alloys with a higher copper content are more expensive; those with a lower copper content are less ductile, and therefore less suited for cold working.

*Mutual-Sunset Lamp Manufacturing Company*

Brass knuckles are being soldered to each end of a Bridgeport seamless brass tube to form the extension arm of a bridge lamp. For this application, Bridgeport furnishes brass of extra strength and rigidity.

Probably the most important application of the copper alloys in defense is the use of cartridge brass for ammunition. Cartridge brass contains approximately 70% copper and 30% zinc. Specifications are very rigid, calling for a brass of exceptional purity. In particular, cartridge brass must be free from any appreciable amount of such impurities as iron and lead. In addition, the metal must be rolled to accurate gage and must be free from foreign inclusions, gas pockets, and surface defects. It must be annealed with a uniform grain structure and at a temperature which results in maximum ductility.

### Other Copper Alloys

Another copper alloy, Commercial Bronze, containing approximately 90% copper and 10% zinc, is used for bullet jackets. (In some Government specifications, this alloy is referred to as Gilding Metal. It is more common practice in the brass industry, however, to use the term Gilding Metal to describe the 95-5 alloy.) The 90-10 alloy is also very ductile and consequently easy to fabricate into drawn work.

For the manufacture of time fuses (such as are used for shrapnel shells) brass rod, containing about 60% copper, 2% lead, and the remainder zinc, is commonly used. Time fuses are usually made from hot forgings. Pure copper is extensively used in the form of rings which are fitted into grooves in shrapnel shells. These rings or rotating shell bands seal off the powder fumes and provide a soft metal contact between the shell and the rifling of the gun. They are made either from sections of copper tubing or by blanking, cupping, and drawing the copper into the required form. The 90-10 alloy is used for this purpose also.

### Communication Wire

Copper alloys also aid in maintaining telephone communication in the field. Bronze communication wire, consisting mainly of copper with a small percentage of tin, is widely used for this purpose, because it is stronger than pure copper wire and will stand considerable abuse without breaking.

While other materials have frequently been suggested for copper and its alloys in many industrial applications where physical demands are not especially severe, no adequate substitute for the copper alloys in armaments has ever been discovered. The unusual combination of properties possessed by the copper alloys is unlikely to be duplicated in other materials.

# COPPER ALLOY BULLETIN

## ALLOYS OF COPPER

*This is the eighteenth of a series of articles on the properties and applications of copper alloys, and continues the subject of modifications of the copper-zinc alloys.*

### ADDITIONS OF TIN TO COPPER-ZINC ALLOYS

One of the elements commonly added to the copper-zinc alloys is tin. The principal reason for this addition is the improved resistance to corrosion, particularly where brass is subject to attack by sea water. Years ago common Muntz metal was found beneficial for protecting the bottoms of sailing vessels. Muntz metal sheathing was used in preference to copper because the gradual dezincification of the Muntz metal prevented the growth of barnacles. The addition of tin to Muntz metal decreased the rate of corrosive attack, while preventing formation of marine growths.

#### Admiralty Condenser Tubes

Ultimately this effect of tin was used advantageously in condenser tubing. Experience had shown the advantages of the 70-30 copper-zinc alloy over the 60-40, and the addition of 1% tin to the former alloy brought about an equally satisfactory improvement. The alloy containing 70% copper, 29% zinc, and 1% tin was originally the mixture adopted by the British Admiralty for condenser tubing, and hence became known as Admiralty. This alloy was first manufactured in this country by Bridgeport.

The addition of tin seems to prevent dezincification. This effect was first noted in the alpha plus beta Muntz metal and was ascribed chiefly to the added resistance of the beta crystals. When added to the 70-30 alloy, tin proved equally helpful to the alpha crystals.

#### Tin in Other Alloys

Some attempts have been made to improve the corrosion resistance of red brass by the addition of tin, but since the red brass has little inherent tendency toward dezincification, any beneficial effect due to to the tin is not readily apparent.

Tin is added to the richer copper-zinc alloys because of its effect on the color and because of the slightly increased strength it gives to the alloy. Such additions are not common because very similar effects can be produced by a simple increase in the zinc content. The presence of tin tends to whiten slightly the normal golden color of the 85-90% copper alloy, and is useful in the jewelry trade when exact matches of color are necessary.

## Switch Contacts Emit Arc-Extinguishing Gas

A novel means for extinguishing arcs in switches and circuit breakers designed to open under load, without the use of mechanical devices, is described in a recent patent. The arc is extinguished, it is claimed, by the emission of gas from the contacts under the heat of the arc.

The contacts, according to the patent, may consist of copper or copper alloys. The contacts are made porous by mixing a quantity of finely divided particles of the copper or alloy with an organic binder, such as soap. The mixture is compressed into a composite mass, and heat is used to volatilize the soap and bond the metal. The contact is immersed in oil or water, and the liquid fills the voids in the sponge-like mass. When the circuit is interrupted, the vapor formed by the heat of the arc acts quickly to extinguish it, it is claimed.

## Pressures Given for Cold Squeezing Steps

Suggested pressures for use in determining needed press capacity for typical cold squeezing operations were listed as follows in a recent issue of *Modern Industrial Press*.

| OPERATION | TONS PER SQUARE INCH |
|---|---|
| Coining bronze | 90–100 |
| Embossing brass | 175–215 |
| Cold forging brass | 15–30 |
| Swaging brass | 60–70 |
| Swaging copper | 70–80 |

## Bronze, Rubber Used In Flexible Bearings

Flexibility in a new type of bearing is obtained by bonding a ring of neoprene or rubber between inner and outer rings of brass or bronze, it is reported. It is said that the bearings can be made in sizes to specification, and in lengths up to four feet, which can then be cut to length as required.

Bridgeport will refer readers to the manufacturer of the bearing.

## NEW DEVELOPMENTS

**Vertical screw-cutting machines,** which were developed abroad, have been placed on the market in this country, it is reported. Outstanding advantages claimed for the vertical machines are reduction in floor space and feeding of stock by its own weight. It is said that the machines also operate more quietly. **(No. 140)**

**A comparator-densitometer** is described as a simple, compact device for measuring the density of lines on spectrogram plates. It is said that the instrument provides means for projecting spectrogram on a viewing screen, and for quickly identifying the spectral lines of 70 elements. **(No. 141)**

**A scrap cutter** is designed for cutting punch press scrap to predetermined lengths, can be used also for cutting finished products to length, according to the maker. It is said that the cutter can be set to operate at any given number of strokes of the press. **(No. 142)**

**A tap and reamer aligner** is said to be accurately machined to permit quick, perfect alignment of tap or reamer over drilled hole. **(No. 143)**

**A stripping compound** removes baked enamels, varnishes, lacquers, paints, and synthetic finishes from metal, it is claimed. Action, it is said, depends on an emulsifying effect that floats away the coating, leaving a clean, bright metal surface. Compound is reported to contain no caustics. It is furnished in concentrated form for dilution with water. **(No. 144)**

**A sulphur-carbon compound** is described as suitable for checking impressions of forging dies and die-casting dies. It is said that the new material is very light, does not shrink, shows the finest markings of the form or die. It can also be used in place of wood patterns, it is claimed. **(No. 145)**

**A polisher's brick** is recommended by the maker for removing oil or grease from wheels before they are reset with abrasive. It is said that the brick is suitable for use on wheels employed for finish polishing. **(No. 146)**

**A production marker** is said to be designed for high-speed identification of round tubular or solid metal parts, such as shells, venturi tubes, and many other products. It is said that the machine is motor-driven, and is automatic except for hand feeding of parts to gravity chute. Speeds up to 7,000 pieces per hour are possible, it is claimed. **(No. 147)**

**A cut-off machine** is said to assist in high-speed production of parts of the type made on automatic screw machines. The machine, it is claimed, can perform the following operations or combinations: stock feed to fixed or swinging stop, form and cut off with two cross slide tools, and one or two end operations, such as threading or drilling. **(No. 148)**

*This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.*


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**COPPER WATER TUBE**—For plumbing, heating, underground piping.

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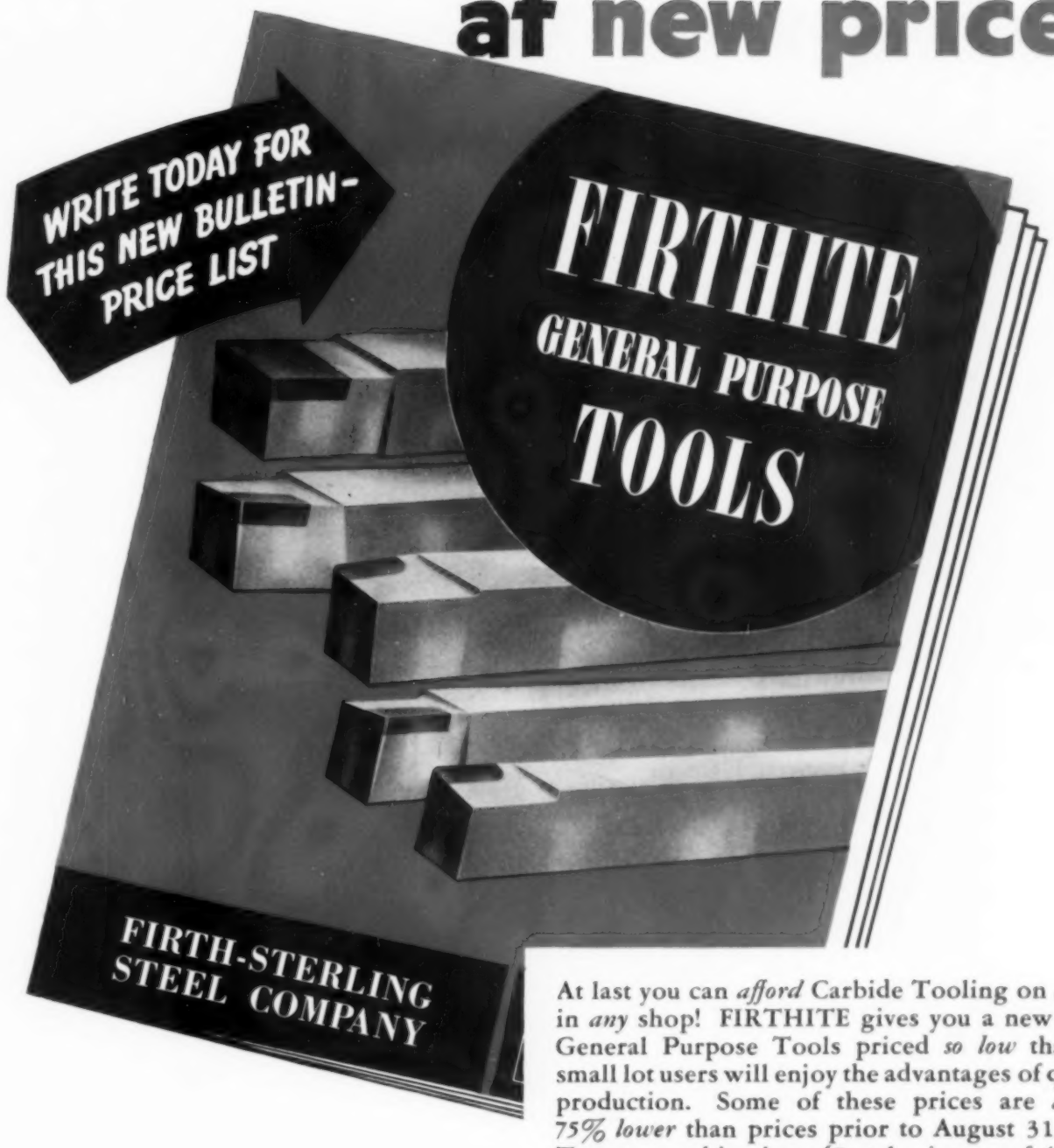


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If you want a better idea of how steel castings can be used to increase production, have one of the foundrymen listed below show you the New Steel Castings Handbook and tell you how to secure your personal copy. This book summarizes the experiences of hundreds of engineers, designers, metallurgists and steel foundrymen. Its 500 pages of facts, ideas, tables, charts and illustrations are designed to help you manufacture a better and more modern product. This book is published by the Steel Founders' Society of America, 920 Midland Bldg., Cleveland, Ohio.

Another aid to up-to-date casting principles is a new sound movie showing modern foundry practice, diagrams and drawings, and many actual steel castings which is also available through the above Society. This 35 mm. picture runs a half hour and can be obtained through your local foundryman or the Society.

For a practical demonstration of what modern foundry practice can do, send your next casting job to one of the organizations listed at the left.

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Ernest E. Thum, Editor



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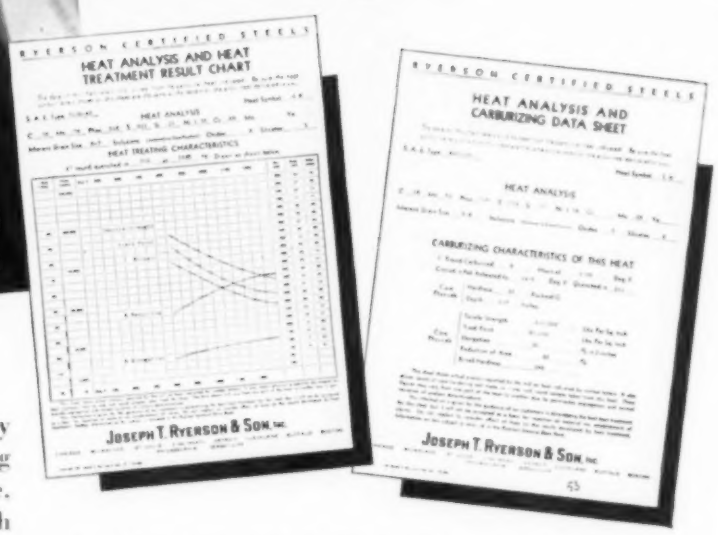
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RYERSON CERTIFIED STEELS

# Production *of* Automotive Castings

By HAROLD S. AUSTIN
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THE IMPORTANCE OF CAST IRON IN automotive construction is well established. About 12 to 14% of the total weight of the automobile consists of cast iron, 5 to 7% of steel forgings, and 1 to 2% of malleable iron. It is probably conservative to estimate that there are no less than 50 separate gray iron castings, large and small, varying in weight from an ounce to 300 lb., used in the automobile.

The subject is so large that even in general outline it is necessary to divide it into two parts, the first of which has to do with the nature and production of the irons, and the second with the specific irons used for the principal classes of parts. First, however, attention should be directed to the iron-carbon equilibrium diagram as presented on page 422 of the October issue of METAL PROGRESS. Information about cast steel (of which a considerable amount is being used in modern motorized vehicles) can be drawn from this diagram directly; the higher carbon alloys of iron called "cast iron" have another all-important element, namely silicon, and it moves the position of the red lines representing the iron-graphite diagram to the left. In other words, the eutectoid and eutectic occur with less carbon as the silicon increases.

Cast steel, high silicon carbon steel, malleable, pearlitic malleable, white and gray cast iron, all contain at least 90% iron. (There are some exceptions to this, such as special compositions where one or more alloys are added to impart unusual characteristics.) The vast difference in the structural constituents, and therefore the physical properties of these several classes of irons, are due almost entirely to the variation in the amounts of carbon and silicon present, and the heat treatment which may be applied. The structural state of the carbon is the most prominent in determining the physical properties of the iron and, in turn, the silicon is the most important factor in determining the structural state of the carbon.

*Steel* contains less than 1.70% of carbon and generally less than 0.30% of silicon, although silicon steel with much higher amounts is not uncommon. Most of the cast steel produced is hypo-eutectoid, with smaller tonnages of eutectoid and hyper-eutectoid steels being melted. Except in some specialties (to be mentioned later) the carbide is stable during cooling and heat treatment; the methods of annealing, hardening and tempering, and the resulting microstructures are well enough known that further attention in this place is unwarranted. However it may not be amiss to renew acquaintance with the structural changes occurring in the common cast irons.

*Malleable iron* contains from 1.75 to 3.00% carbon, and from 0.50 to 1.25% silicon. As cast it is a low carbon white cast iron of hypo-eutectic composition, and as the metal passes through the liquidus austenite is precipitated. When the temperature reaches that of the solidus, the remaining mother liquid, the eutectic, solidifies. As the cooling continues through the zone between the solidus and $Ar_{cm}$ (line *SE* on the diagram), the constituents consist of austenite and the austenite-cementite eutectic. When $Ar_{cm}$ is passed, pro-eutectoid cementite is precipitated at the expense of carbon in the austenite, and, at the $Ar_{1,2,3}$ point, the austenite is of eutectoid composition and transforms to pearlite. The final structural constituents are pearlite, pro-eutectoid cementite and eutectic cementite.

Iron in this state has very limited application, as it is weak and brittle. Fully annealed malleable is made from this iron by heating up to and soaking at temperatures of 1500° F. or

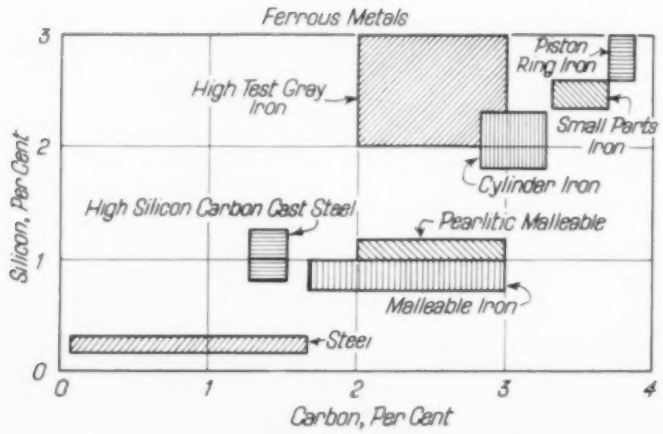



*Diagram Showing Range of Carbon and Silicon Content in Important Classes of Automotive Castings*

more for about 90 hr., followed by slow cooling at 20 to 30° per hr. During the soaking period, the cementite changes, thanks to the presence of silicon, into ferrite and graphite, the latter as segregated masses of temper carbon.

Pearlitic malleable is a modification of standard malleable, and usually contains a slightly larger amount of silicon. By means of an arrested anneal or by reheating followed by accelerated cooling, a large part of the carbon is retained in the combined state to form lamellar pearlite or spheroidal cementite. This product is finding much wider applications in automotive work.

*Gray cast iron* is the most complex in structure of all of the ferrous alloys. The amount, character and distribution of the graphitic component is the greatest single factor in determining its physical properties.

By far the largest bulk of castings is made of hypo-eutectic iron. Very small castings are made of compositions very near that of eutectic or even slightly hyper-eutectic compositions.

Hypo-eutectic gray iron has a range in carbon content from about 2.00 to 3.50%, and in silicon, generally from about 1.50 to 3.00%. Theoretically, the constituents would be identical with those previously described in white cast iron if it were not for the presence of a considerably larger silicon content. As a result, instead of having eutectic and pro-eutectoid cementite precipitated during the cooling from the liquid state, flake graphite is formed due to the disintegration of the unstable cementite. By controlling the amount of carbon and silicon in the mixture suitable to the size and design of the casting and the cooling rates to be experienced, the structural constituents may be modified and held within specified limits. The final constituents usually found are pearlite and flake graphite; ferrite may be present, and always small amounts of steadite, the phosphorus-rich component. The amount of the latter depends on the percentage of phosphorus in the iron.

In the table below will be found representative values of physical properties of these alloys. Wide ranges are quoted; the properties may be narrowly adjusted by composition, manufacture, and heat treatment to fit the requirement of almost every place where irons and steels are applicable.

## *Advantages of Cast Iron*

From a comparison of the physical properties of cast iron and steel — in which it is seen that steel is stronger, more ductile and far superior in impact values — one not familiar with other characteristics of cast iron would naturally wonder why gray iron has found any extended use in industry when steel and malleable iron are available.

There are many logical reasons why cast iron is so extensively used, and to the surprise of probably all of us, it is broadening its sphere of usefulness.

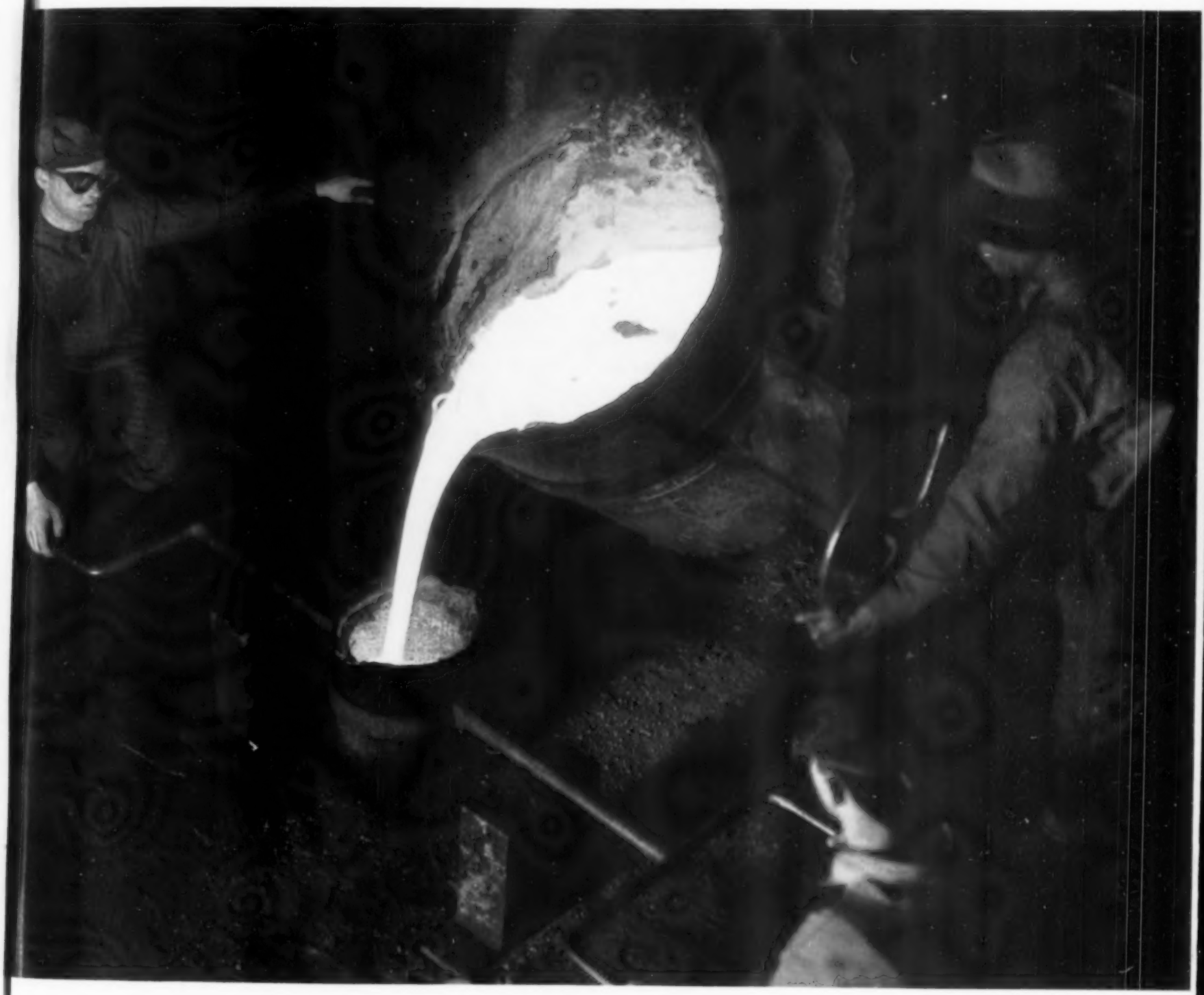
From an economic viewpoint, cast iron is the cheapest to produce of all metals. The first

**Mechanical Properties of Commercial Castings**

| Material | Modulus of Elasticity | Tensile Strength | Yield Point | Elongation | Brinell Hardness |
|---|---|---|---|---|---|
| Wrought iron<br>Annealed malleable iron | 25 to 27,000,000 | 50 to 60,000 | 32 to 38,000 | 15 to 40% | 110 to 140 |
| Pearlitic malleable | 26 to 28,000,000 | 60 to 80,000 | 35 to 45,000 | 15 to 8% | 170 to 215 |
| Cast steel | 30,000,000 | 60 to 150,000 | 30 to 125,000 | 25 to 10% | |
| High silicon, high carbon cast steel (heat treated) | 30 to 33,000,000 | 100 to 130,000 | 60 to 80,000 | 10 to 4% | 225 to 250 |
| Small parts iron | | 28 to 34,000 | | | 160 to 200 |
| Cylinder iron | | 35 to 40,000 | | | 200 to 250 |
| High test irons | 22,000,000 | 50 to 100,000 | | | 200 and up |

This excellent foundry picture has been in METAL PROGRESS' files for several years; unfortunately its source is unknown so the desired acknowledgment cannot now be given.

*The Transfer Ladle*



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product obtained from the smelting of iron ore is pig iron; this is nothing more nor less than cast iron, and it could be used directly as-cast from the blast furnace for many kinds of castings where strength, soundness, and high pouring temperatures are not essential. Cast iron is admirably suited for casting into intricate shapes possessing light and heavy sections and varying in weight from an ounce to many tons. Understand, of course, it is not inferred that the same composition of cast iron can be used under all of these diverse conditions. Cast iron is very fluid in the molten condition, solidifying at about 2200° F., a much lower temperature than steel and malleable iron. It can be cast with comparative ease, with a minimum amount of burning-in of molding and core sands and thus is cheaply cleaned. Finer grained molding and core sands can be used and, with refractory washes and sea-coal, comparatively smooth castings are obtained. Possessing a much lower factor of shrinkage than either steel or malleable iron during the solidification, sound castings may be produced with the least amount of remelt in the form of sprues and risers. Annealing is required in only a few cases and is comparatively simple and inexpensive. Gray iron has the characteristics and capability of free cutting and rapid machinability, and may be cast close to specified size with the minimum amount of material to be machined off.

One of the most valuable properties of gray iron is its resistance to wear. It is an ideal material for use in moving parts and its structural components (a matrix of pearlite and uniformly distributed flakes or nodules of graphite) develop a smooth, mirror-like finish on the contact surfaces.

### *Melting Furnaces and Accessories*

There are many types of furnaces and accessories used in the manufacture of cast iron. By far the most common and most economical operating unit is the cupola, using coke as a fuel. The air furnace is used to a more limited extent; and in recent years, the use of the electric furnace, rotating powdered coal or oil fired furnaces, and combinations of blast furnace, converter, cupola, electric furnace or air furnace and mixers, are becoming more numerous. These newer mediums of melting are used to meet the demands for irons of greater strength and special compositions which, it is thought, are out of the range of cupola practice. The introduction and development of new types of furnaces and processes have been quite active in the past ten years and with varying degrees of success.

The cupola and cupola practice have also been given as much attention as the other forms of melting, with at least an equal degree of improvement in efficiency and in the quality of its product. Cupolas which a few years ago were melting at a maximum capacity of 15 to 20 tons per hr. may now be made to produce 25 to 30. The length of heats and total daily tonnage have been materially increased to extend over periods of 24 to 36 hr. and even a week of continuous melting, with double and more the tonnage.

Along with the progress in metallurgical practice, heavier demands have been placed on refractory quality and life. This is a real problem in modern cupola practice because high tapping temperatures (2800 to 2950° F.), in conjunction with slag reactions, penetration, and abrasion by stock at such temperatures, are playing havoc with our linings, causing fusion, rapid wearing away, and shrinkage of the refractory blocks. I know of no refractory that will withstand the severe condition in the cupola melting zone for an appreciable time. Longer heats have been obtained mostly by means of sheer mass — increasing the thickness of the lining. This is not intended as any reflection on the refractories industry; it is merely stated as an opportunity for improvement, worthy of more attention by ceramic experts.

At the present time there are numerous hot blast cupolas in operation, as well as cupolas with adjustable tuyeres; cupolas using oil or combinations of oil and coke for fuel; cupolas with pre-heated air blast using powdered coal for pre-heating — all designed for more economical melting of lower grade scrap or higher percentages of steel scrap, or for the production of compositions considered outside of the range of the ordinary cupola.

Improvement in quality has kept pace with efficiency in melting. At the present time we have the means at our command to control to a very high degree the uniformity in composition and structure of cupola iron. A specific example may be cited in foundry practice for piston rings:

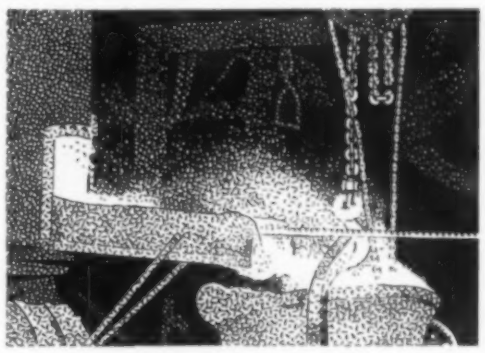
There are at least three physical characteristics that must be very carefully regulated in piston rings, namely, hardness, strength and resilience. Compositions of iron for the larger

sizes of rings may consist of anything from small parts iron to the highest grade of cylinder iron. Small rings require, probably, the softest grade of gray iron that it is possible to produce, although the requirements in the finished castings are just as rigid as for those in any other type of casting.

In the melting of cupola iron for small piston rings, special consideration must be given to such matters as cupola dimensions. Here, the capacity of the hearth, the time the metal is subjected to contact with the white-hot coke in the bed, the amount and composition of the slag, as well as the details of cupola operation and grade of coke used, all produce very appreciable changes in the composition and chilling characteristics of the iron.

Regulation of the amount of combined carbon is of prime importance. There are two very effective means by which this constituent may be controlled, namely, by the per cent of silicon in the composition, and by the per cent of foundry returns or cast iron scrap in the furnace charge. The higher the silicon and the lower the amount of foundry returns, the lower will be the combined carbon.

The chill depth depends on the size of the ring and the hardness specified; for very small rings it should be negligible. One of the most prevalent sources of trouble in the production of piston rings is chilled iron, and for that reason, piston ring foundries have taken extra precautions in the way of equipment and practice to overcome the difficulty. It is well known that the amount of moisture in the cupola air blast influences the chilling characteristics of the iron; this is quite noticeable on damp warm days. Even in foundries where much larger work is cast, equipment is provided for the purpose of determining the weight of water contained in the air in order that changes may be made in the cupola charge and coke ratio, and thereby anticipate and counteract the effect of excessive moisture in the blast. The piston ring foundry has gone one step further in the elimination of this source of trouble by dehydrating the blast. Numerous installations for this purpose are now in operation.



### *Effect of Cooling Rate on Properties*

Like most other metals and alloys, the physical properties of gray cast iron are greatly affected by the cooling rate during solidification and down through the critical range. This influence is so tremendous that the properties of the metal can be completely changed thereby, and the metal made unsuitable for the purpose intended. The cooling rate may be so rapid that a chilled iron is formed consisting of austenite, martensite, sorbite and cementite. The fracture then has a dense, white, silver colored appearance; the iron is extremely hard; it is unmachinable at production speeds and would play havoc in the machine shop.

There are two principal causes for chilled iron in gray iron castings. Either the design of the casting may be largely responsible, with thin sections too light for the grade of iron required in the casting, or the composition of the metal may not be correct for the size of the casting. There are a multitude of other conditions which may also cause this trouble, such as gates improperly located, gates and sprue cross sections of inadequate size (slow filling of the mold), flowing distances of the metal too far over thin sections of cold surfaces, and so on.

Of course this same phenomenon of chilling, on the other hand, is used to advantage in certain types of castings where extreme hardness is required, the desired condition being produced by iron chills placed in the mold, covering the surface to be hardened.

The influence of slow cooling must also be taken into consideration. Too slow a rate may produce changes in the metal which are equally objectionable, such as soft porous iron, due to the growth of the graphite flakes to excessive size. Here again, the design or the composition is the principal cause of the trouble. Pouring temperatures also must be controlled.

It is evident from the foregoing that both hard and soft iron may exist in the same casting. In automotive work where machining, wear and strength are generally to be considered, this is an intolerable condition. Fortunately, we are able to overcome or minimize it by regulating the basic composition, by altering the molding practice, or by using alloys.

### *Heat Treatment*

Cast iron is receptive to heat treatment. It may be quenched, normalized, annealed and tempered. By quenching gray iron from temperatures above 1500° F., the original hardness, 200 Brinell or less, may be raised to over 500. At lower quenching temperatures, the appearance of the fracture is changed but little, although the hardness may be materially increased. At higher quenching temperatures, the characteristic silver colored fracture may be obtained. Hardening may also be accomplished by air quenching. Localized hardening may be produced by rapidly heating the part to 1750 to 1850° F. and relying on the mass of the cool portion to abstract the heat.

Annealing is now a very common practice. Annealing temperatures range from 900 to 1400° F. Maximum softness is usually obtained at 1400° F.; at this temperature, the combined carbon is completely reassembled as graphite. Any degree of softness above the minimum may be obtained by regulating the annealing temperature. The original hardness of the casting must be taken into consideration; all other conditions remaining constant, the higher the original hardness of the metal, the higher will be the final hardness after annealing. Chilled spots may be softened sufficiently to become machinable by heating to 1700 to 1800° F. for 30 min. or more and cooling slowly to below 1400° F. Annealing usually has a slight weakening effect on gray iron, but probably not to the extent generally believed; it usually lowers the strength less than 10%.

Quenching and tempering is quite feasible. Such treatment has been found to strengthen gray iron and is probably the best way to remove internal strains. The treatment is more effective in low carbon irons. Tempering temperatures usually range from 400 to 700° F.

Heat treatment is common today as a routine procedure for many parts.

### *Metal Control*

Good metal control has had much to do with the progress of automotive cast irons. No doubt extra effort has been extended because of the stringent specifications promulgated by the automotive engineer and enforced by thorough inspection. By "metal control" I refer to the system employed for checking and controlling the raw materials, the melting practice, and the composition and physical properties of metal in castings.

We all recognize the importance of raw materials; it extends back to the quality of the iron ore, the blast furnace practice, the coke, and a multitude of other details.

In the production of uniform, high quality iron, conforming to strict specifications, it is absolutely necessary that rapid and reliable check methods be available for the control of the metal at all times. Fortunately, suitable methods have been developed and are being used in modern foundry practice.

The chill test, supplemented by frequent chemical analyses, is applicable with slight modifications to almost any foundry environment and melting equipment. It has been found to be an exceptionally quick and reliable control test for gray iron. Many different test pieces have been designed; usually two or more designs should be employed as it is almost impossible to obtain all of the information desired from one only. For efficient control, a chill test should be of such design that information as to the chill depth and fracture of the iron can be obtained within a fraction of a minute. With tests of this character available, the trend of the metal can be watched. The hardness of the chill test is comparative to that of the casting and is valuable for anticipating and controlling the hardness of the product.

If identifying numbers are stamped on the mold when made and assembled, the time of the hour noted when the mold is poured, and the chill tests racked up in partitions showing the time the tests were taken, the foundry will have a system of relating the chill tests with the individual casting. The value of this method of checking cannot be overestimated. A complete history may then be obtained from the time the metal is tapped until the casting has passed through the machine shop. Other check tests include fluidity, contraction, transverse strength, impact.

Considerable research work is being done with spectrographic analysis of gray iron for control purposes to supplement or replace the much slower chemical tests in which so much valuable time is consumed in sampling. Spectrographic routine control tests are now being employed by more than one large gray iron foundry, and the future for this method looks very favorable. Research work in chemical, electrical and optical methods may also develop other rapid methods of analysis.

# Modern

# Bright Plating

By JOSEPH B. KUSHNER
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New York City

THE FACT THAT IT IS POSSIBLE TO OBTAIN a bright electrodeposit of one metal on another was discovered just about 100 years ago, almost contemporaneously with the birth of electroplating itself. At that time, JOHN WRIGHT, a plater working for the firm of Elkington Brothers, Silversmiths and Gilders, Birmingham, Eng., observed that a silver plating bath he had inadvertently contaminated with carbon disulphide gave much brighter silver deposits than the other silvering tanks on the premises. As the story goes, WRIGHT promptly sold his discovery to his boss and it would have been a closely guarded secret to this very day if another worker in the plant hadn't gotten wind of it and just as promptly cashed in on it by selling it to Elkington's bitterest competitor the following week!

In spite of this early and rather typical beginning, the development of bright plating during the first 90 of the intervening years since that eventful day was extremely slow. Platers and a few interested chemists noted, for example, that small additions of cadmium salts to a nickel bath seemed to brighten the nickel deposits; they noted that certain colloidal materials such as glue and gelatin when placed in minute amounts in acid copper plating electrolytes gave finer grained, smoother deposits of copper; arsenic seemed to brighten brass solutions; lead, cyanide copper solutions. But these deposits were brittle in the extreme, were of limited brightness and did not hold their brightness if plated in thicknesses greater than a few hundred thousandths. Thicker deposits assumed the dull matte appearance obtained from regular plating baths and had to be buffed in order to bring up a good luster. Furthermore, the brighteners used, poor as they were, had to be controlled by guesswork, as no chemical methods were available for their analysis or control.

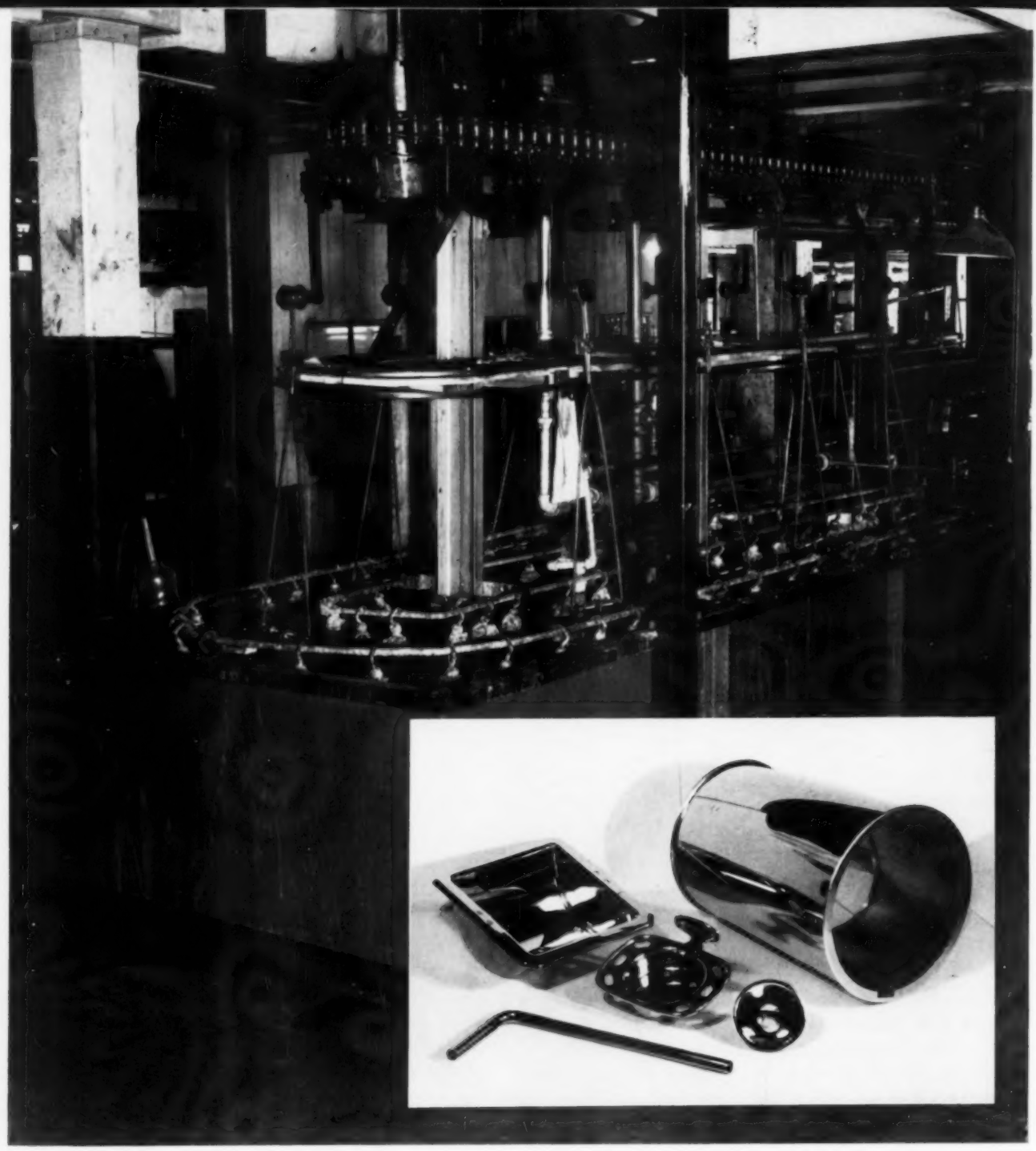
Then overnight something happened. In 1929 MAX SCHLOTTER promulgated a bright plating theory in the German publication *Korrosion und Metallschutz* and announced the first commercial bright nickel solution. It gave practically mirror bright deposits for considerable thicknesses of metal. It was a literal "shot in the arm" for the then dormant electroplating industry. Chemical suppliers, chemists and metallurgists became interested in this long neglected stepchild of metallurgy. At that moment, barely a decade ago, bright plating graduated from a cook book art to the modern, scientifically controlled and engineered electrometallurgical process of today.

The theory propounded by SCHLOTTER will not be gone into here, as this is intended to be a general description of modern bright plating methods. Several points about the mechanism are still moot but the essence is this: Certain organic and metallo-organic compounds, when added to metal plating electrolytes, interfere with the growth of the deposited metal crystallites in such a manner as to *(a)* reduce the crystal size to such a small value as to make the grain boundaries of smaller dimensions than the wavelengths of visible light and *(b)* orient the crystallites in one plane. These two factors cause the metal deposits to be sub-microscopically smooth with a resultant maximum reflectivity and brightness.

## *Bright Nickel Plating*

The outstanding example of modern bright plating is nickel. The earlier commercial bright nickel plating processes had poor throwing power and tended to produce rather brittle, non-ductile deposits of limited brightness, but these faults have to a large extent been corrected and today the metal manufacturer who has occasion to use nickel plating saves considerable amounts of money by being able to eliminate polishing and buffing after the nickel coat is on. Polishing labor, equipment and space costs are reduced to a minimum. Routing and handling operations are simplified, no re-racking is required between the nickel and the chromium plating tanks, and rejects due to cut-through on the buffing operation are reduced to the vanishing point. These and a number of other advantages are available to the metal fabricator because of the efficiency and effectiveness of modern bright nickel plating.

There are five or six commercial methods on the market today, falling into two classes:



*Full-Automatic Installation for Modern Bright Plating, and Some of the Work Done. Courtesy, The Seymour Mfg. Co.*

1. Processes which make use of organic addition agents solely.

2. Processes which make use of other metals as well as organics.

The organic compounds used generally fall into the sulphonated naphthol groups (one exception to this is a process involving the co-deposition of cobalt in the presence of formates and formaldehyde), although newer and better organics are frequently being added to the roster of brighteners as research progresses.

Almost all of the modern bright plating electrolytes contain surface tension depressants which lower the surface tension to about 32 to 37 dynes. These help reduce pitting to a minimum by preventing the adherence of gas bubbles and foreign matter to the cathode surface.

The basic nickel plating solution used is the hot Watts bath in which the concentrations of the components run something as follows:

| | | | | |
|---|---|---|---|---|
| Nickel sulphate | 20 to 40 | oz. | per | gal. |
| Nickel chloride | 4 to 8 | " | " | " |
| Boric acid | 4 to 6 | " | " | " |

Brightening addition agents as required

These baths are run at temperatures ranging from 85 to 165° F., and are kept within the pH range of 2 to 4.5, although some go as high as 5.8. Most of the baths require agitation, and this is best imparted by cathode motion. The permissible current densities are high, running from 20 to 120 amp. per sq.ft. of cathode area. Cathode efficiency is quite high, averaging about 93%.

Deposits of nickel under these circumstances are continuously bright but, in order that best results be obtained, the basis metal must be suitably prepared by buffing, as any roughness on the

metal is greatly magnified by the nickel plate. However, excellent results can be obtained by bright nickel plating over semi-lustrous deposits such as are produced by the rochelle-salts copper plating bath.

The solutions are very susceptible to impurities and must be purified when contaminated. Filtration through activated carbon is generally sufficient to remove extraneous organic matter and dirt. Vagrant metals are usually removed by chemical treatment or by electrodeposition on dummies at low current densities.

Containing tanks for the electrolytes are made without exception of rubber coated steel and range in size from 10-gal. manual tanks to 33,000-gal. automatic installations capable of plating millions of pieces daily.

With consistent chemical control of the solutions — that is to say, the metal content, pH, chlorides, boric acid, surface tension and brightener — these processes are capable of giving excellent results over an indefinite period of time.

### *Bright Copper Plating*

Acid copper baths have always been made to give, if not bright, at least smooth and fine-grained deposits by the use of such agents as glue, gelatin and phenolsulphonic acid. As yet there is no genuine bright copper process from acid solutions on the market, but this is perhaps because there has not been such a need for bright copper deposits as there was for bright nickel. There is, however, a great deal of work being done in some of the commercial and university laboratories on the subject and doubtless such a process will make its appearance in the near future.

The cyanide copper baths give fairly bright deposits when limited amounts of lead salts are added but the deposits are extremely brittle and the lead content hard to control. A revival of the use of rochelle salts in copper plating baths has led to finer-grained deposits. These deposits are not truly bright, though; they are smooth and semi-lustrous, particularly as the deposits become thicker. (The same holds for the rapid copper process put on the market a few years ago; deposits are bright for the first few minutes of deposition, and then gradually assume a semi-lustrous appearance.) The particular bath that the writer has reference to is a highly concentrated rochelle salt solution with the addition of certain unnamed wetting and brightening agents. Its particular advantage is that with it very thick coatings of copper in smooth form can be deposited in short periods of time, since the cathode efficiency of the process is 100% and the permissible current density may run as high as 100 amp. per sq.ft. or more. Since the copper is in the cuprous form, one can plate deposits as heavy as 0.033 in. in approximately 2½ hr.

In the very recent past two new types of alkaline bright copper plating solutions have been introduced which seem to offer possibilities for plates as bright as are obtainable with nickel. One of these is based on the deposition of copper from pyrophosphate solutions. The other is based on the deposition of copper from solutions containing organic amines such as diethylene triamine.

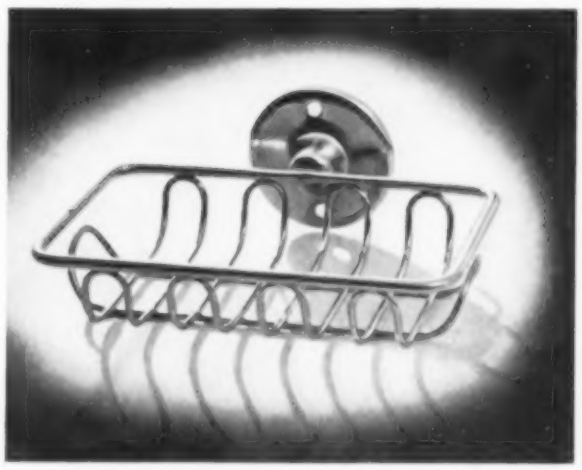
### *Bright Silver, Cadmium and Zinc*

*Silver,* which almost without exception is plated from its cyanide solution, is still brightened by the use of carbon disulphide, the first plating brightener on record. Unfortunately, this reagent is difficult to control and does not produce really bright deposits. Deposits from a bath containing carbon disulphide are rather milky and must be wheel fanned before a real luster can be had.

Two years ago, EGEBERG and PROMISEL made an extended research on silver brighteners. Starting from the idea that complex carbon disulphide breakdown products are responsible for the brightening action in the silver baths, they discovered that certain of the organic sulphide compounds are superb brighteners for silver. Derivatives of the thiocarbamic acids have been recommended.

At the present time there are a few methods on the market for depositing *zinc and cadmium* in bright form. Cyanide solutions are used and the chief brighteners are complex organic compounds.

In closing this brief review of modern bright plating methods it may be said that the greatest advances in bright plating have been made almost exclusively in the field of bright nickel. However the future of bright plating of all metals looks good, and the writer predicts that in the not-so-far future all plated metals will be deposited in mirror bright form.



*Bright Nickel Plated Ware (The Udylite Corp.)*

# Rapid Preparation *of* Lead Sheath *for* Metallography

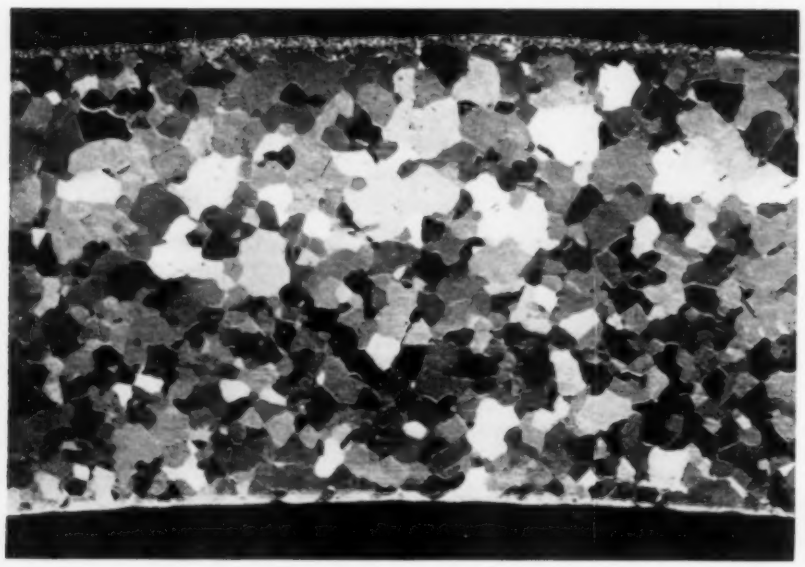
By I. A. ROHRIG
Research Department, Detroit Edison Co.

A METHOD OF MICROTOME CUTTING OF lead cable-sheath specimens, as described by H. P. NIELSEN in METAL PROGRESS last August, was of interest to the personnel at the Research Laboratory of The Detroit Edison Co. inasmuch as a method for the surface preparation of lead sheath specimens involving the use of a rigid cutting blade was developed at this laboratory and, in its present form, has been in use for nearly a year.

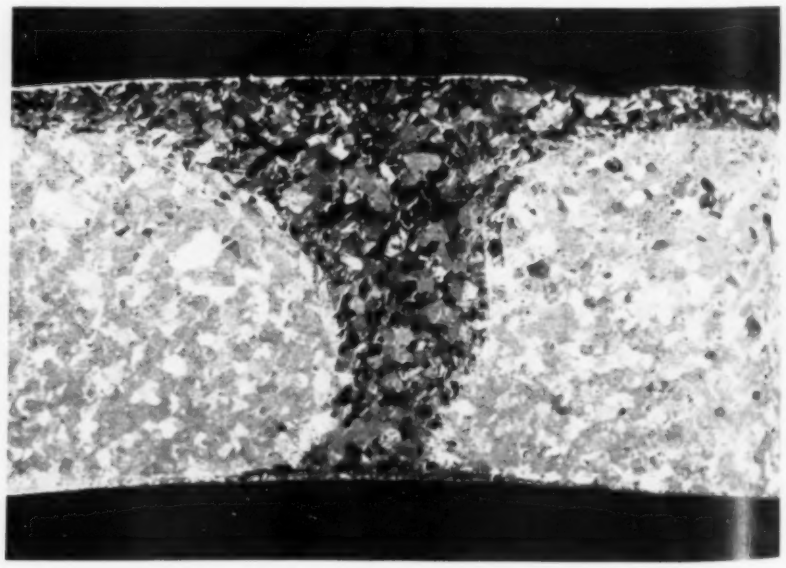
The method is similar to microtome cutting as described by FRANCIS F. LUCAS in his paper, "Application of Microtome Methods to the Preparation of Soft Metals for Microscopic Examination", presented before the American Institute of Mining and Metallurgical Engineers in February, 1927, with the exception that the only equipment necessary is a lathe, which is usually available in any laboratory, and a carefully sharpened cutting blade.

Briefly, the method for preparing the rings of sheathing used for metallographic examination is as follows: A ring of the sheathing is gripped in a lathe chuck and revolved at a speed of about 40 r.p.m. while the surface is shaved by a sharp cutting blade. The setup employed is shown in the adjoining halftone. The knife-edged tool shown in the tool holder is made of an ordinary cut-off tool blade that has been carefully sharpened to a very fine edge. The saw-cut edge of the sheath is removed with a roughing blade, after which the sharp finishing blade is substituted and several very fine cuts are made. The roughing blade and finishing blade are the same with the exception that the roughing blade is not so carefully sharpened.

It is a simple matter to remove finishing cuts less than 0.001 in. thick and obtain a relatively good surface that can be etched and examined without any intermediate work such as polishing. Although slight circumferential scratches may be seen on the surface of the specimen, these can be removed in subsequent etching to reveal



*Grain Structure of Good Quality. Plain Lead Sheath*



*Lead Sheath With a Prominent Die Weld*

the structure of the metal.

It has been found that an angle of about 60° on the cutting edge of the blade and a clearance angle of about 5° between the blade and the work permits a satisfactory cut. Various other combinations may work equally well.

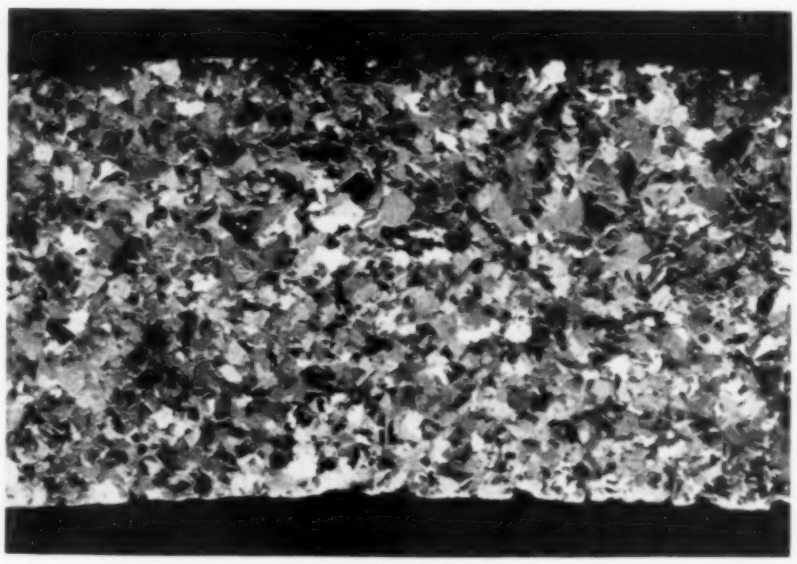
Specimens can be prepared for etching in a few minutes. Furthermore, rings as short as ¾ in. long can be used, which facilitates handling during etching.

The surface obtained after careful cutting and proper etching is suitable for examination and photographing at magnifications up to about 500 diameters; however, 15 to 20 diameters is usually high enough for lead sheath. Various etching reagents may be used to develop the microstructure. We favor the use of 50% acidified ammonium molybdate followed by various mixtures of glacial acetic acid and hydrogen peroxide.

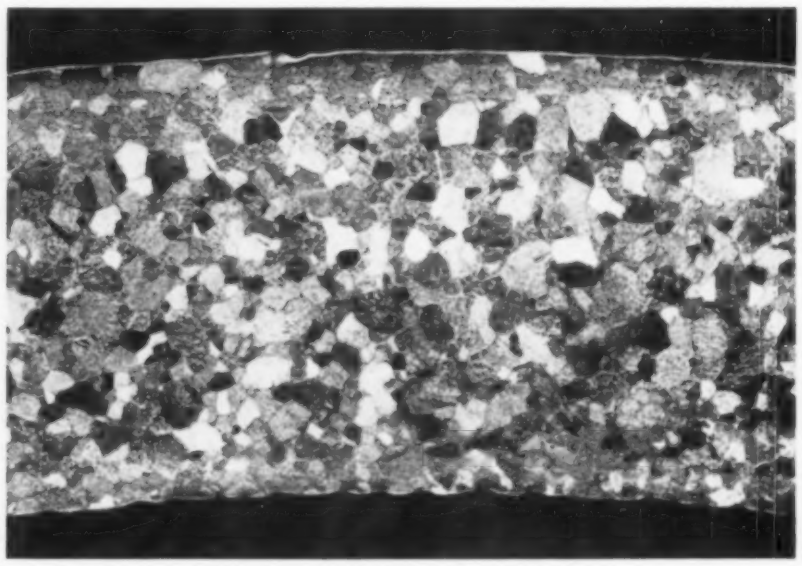
*Lathe Tool Shaving a Specimen of Lead Sheath*

Several types of lead sheath structures are shown in the accompanying photomicrographs, made from specimens prepared by the method outlined. All micros are at 15 diameters and etched in acidified ammonium molybdate, followed by glacial acetic acid plus hydrogen peroxide. The first shows the structure of plain lead sheath of good quality. The next shows a prominent die weld caused by the converging of a new lead charge with the old charge. The others show the structure of two alloy types of lead sheathing, both of which are much harder and stronger than plain lead, namely calcium-lead containing approximately 0.030% calcium and a lead alloy containing small amounts of calcium, bismuth and tin.

The method described has been used for the surface preparation of specimens of lead water pipe and it is probable that it may be applicable for the surface preparation of some of the softer lead-base alloys used for purposes other than cable sheathing or water piping.



*0.030% Calcium-Lead*



*Lead Hardened by Small Amounts of Calcium, Bismuth and Tin*

# Critical Points

By THE EDITOR

TO COLUMBUS, AND AT OHIO STATE University found WILLIAM MCCAUGHEY, professor of mineralogy (in pronouncing his surname change the a to o and eliminate the ughe), thinking about such diverse things as a theory that the petrography of ancient iron slags would give a clue as to the place where iron smelting originated, and the modern difficulties with openhearth slags arising from the ever-increasing load of alloys in the steel and iron scrap. Together we walked across the campus, alive with ROTC squads learning to march, to call on WILBER STOUT, State Geologist, whose life-long hobby has been the collection of facts about the 250-odd blast furnaces erected in Ohio since 1800. Originally a blast furnace chemist, he early learned how much fun it is to scout around and locate a small slag dump, a mound of unused ore, a square foundation, a conical stump of masonry lining — all that remains of a furnace that supported a small community for a generation, giving a living to 50 families and an inheritance to one or two. In his rambles he talked with old settlers, rummaged in attics and trunks for forgotten pictures and documents, and eventually paid helpers to search the tax records and early newspaper files. Some paintings and drawings show what the very early ones were; wet-plate photographs would enable one to reconstruct completely certain furnaces operating in 1850. Maximum production of charcoal iron was achieved during that decade; 30 active furnaces all together made 300 tons a day — one quarter the capacity of a single 1940 furnace! Charcoal becoming scarcer, coal was used, and output per furnace jumped six to eight-fold. Many of the furnaces using ore from the Hanging Rock seam in southeastern Ohio supplied forges for the manufacture of wrought iron; northern furnaces smelting bog ore high in phosphorus made castings — stove plates, grate bars, kettles, andirons, gudgeons. Castings were castings, then, to judge from old advertisements advising the populace to call at the furnace and select their needs from a large stock on the shelves.

***A History of Iron Furnaces in Ohio***

TO WRIGHT FIELD, near Dayton, where the U. S. Army does all its testing of aircraft and accessories, and was shown about the well-equipped and staffed Materials Laboratory, built up during many years under its chief, J. B. Johnson ⊜. Saw many special devices for testing constructional details such as self-locking nuts and cable assemblages, as well as laboratories for studying metals, fabrics, rubber, lubricants and finishes. Was interested to find that the U. S. Army builds no aircraft, depending on commercial industry to design and produce them. Improved ships come about in this way: After studying the existing types and after consultation with builders as to the implications of research at Wright Field and experience elsewhere, the War Department issues performance specifications for a new ship — its ceiling, speed, rate of climb, range, armament, engine, crew — and asks for bids. Any builder who thinks that such a ship is possible then designs it according to his own ideas, makes wind tunnel and other tests, builds one sample complete and submits it with the bid. Sometimes more than one builder is successful in meeting the specifications, as determined by tests at Wright Field, and the order is then divided. To get this Army business, therefore, and comply with the laws requiring Governmental purchases after competitive bidding, the builder must have a going plant and a pot of money to risk. Under special circumstances the design only is submitted and the best of the designs is purchased. In the present accelerated program of building up the national defense, Congress has authorized the purchase of modern types of aircraft by direct negotiation with the builders. . . . . Various units at Wright Field are interested in improving accessories, such as carburetors, instruments, propellers, armament, and are continually designing and constructing experimental units, but even these enter production in private plants. Under these circumstances it might seem that the Materials Laboratory was "an accessory after the fact", but its studies of materials are continually establishing and raising the standards of excellence which all vendors and contractors must meet or exceed. A very minor part of the work is the investigation of service failures — the

***How the Army Gets Better Aircraft***

attempt here is to discover any epidemic of trouble and check it before it gets more than started.

DISCUSSED with RICHARD KENNEDY, my guide and informant at Wright Field, the problem of welding S.A.E. X-4130 (chromium-molybdenum steel) so widely used in the form of tubing, plates and forgings for engine mounts, landing gear, and for structural skeletons for training planes. In his opinion, cracks alongside the welds (made with low carbon steel filler rod) are largely the result of unskilled welding, and are avoided by proper manipulation of the flame so that the surrounding region is mildly preheated, welded with minimum of delay, and then "let down" or cooled slowly enough so the alloy steel margins do not air harden but in effect are normalized. The Materials Laboratory at Wright Field has found that some heats of steel are more susceptible to cracking than others, and has roughly correlated this with the hardenability of the particular sample. Chemical composition must therefore be held within closer limits than the S.A.E. specification; to meet the situation two new Air Corps specifications are under consideration, one for a fine-grained lower carbon type (carbon 0.27 to 0.33) which can be more readily welded into parts that need not or cannot be heat treated and are designed on the basis of normalized metal (minimum yield point 75,000 psi.), and a higher carbon type (carbon 0.32 to 0.39) which is suitable for welded assemblages heat treated to double that strength. As KENNEDY points out, it is no easy matter to design, weld and treat an assemblage of tubing, plate and forgings of varying wall thickness and mass, which, after oil quenching, will have hardness (strength) uniform enough to be acceptable.

***Crack-Free Welds in Aircraft Tubing***

WELDING OF ALLOY STEEL without cracking or dangerously embrittling the metal alongside is also an acute problem in tank construction. Col. GLEN F. JENKS has stated before many Chapters of the American Welding Society (of which he currently is president) that the Ordnance Department is anxious to find a good welding method for armor plate, other than the European dodge of covering the scarf with austenitic stainless steel before the plate is heat treated, and then welding against these austenitic surfaces. A typical problem is this: The plate is 1 in. thick; its alloy content is slightly higher than S.A.E. steels of optimum physical properties, its carbon content above the limit of ready weldability even before hardening; it is carburized on the outer surface to hyper-eutectoid composition and the penetration of carbon may be one quarter the thickness; it is trimmed and machined; it is spray quenched on the carburized side to C-55 hardness. Joints between such plates and between plates and supporting structure must be welded so that the welds contain no cracks and the joint, when hit by a projectile, will not crack but have ballistic properties almost equal to those of the unwelded portions. . . . . This is a much harder job than to weld a pocket sample so it will not fall apart if dropped on the floor!

***Who Can Weld Armor Plate?***

CONTEMPLATING the possibility that the Ordnance Department has gone from the one bottleneck of high grade steel castings to the other bottleneck of high grade alloy steel weldings. After the World War all field artillery was remodeled to decrease weight and increase mobility and power. Unfortunately, governmental rules for purchasing on the price basis tended to exclude really high grade steel castings, and the ones procurable were not good enough. So gun mounts were redesigned of low alloy, high strength steel weldings and enough work done at Watertown Arsenal and elsewhere to indicate that the designs were adequate and weldable. Ordnance officials now seem sure that there will be no difficulty in getting these mounts in sufficient quantity, but one may wonder whether there is not a disturbing industrial parallel: During the depression of the early 1930's, there was little or no business, and energetic staffs figured out a lot of new and more economical manufacturing methods that looked fine on paper but often developed unforeseen and serious difficulties in 1937 when there was some production to try them out on. Similarly the Ordnance Department for 20 years has had no war business and in that time has planned many improvements; now when business is coming back in a big way it is too much to expect that production will flow forth without a hitch here and a tie-up there. Would it not

***Steel Castings Are Still Good for Gun Mounts***

therefore be the course of wisdom to use lightest weight steel weldings for fast motorized artillery, but go back to slightly heavier steel castings for mounts of guns like, say, anti-aircraft which will be required in great numbers to guard industrial centers, and which need be moved only if spotted?

AT THE AMAZING National Cash Register plant in Dayton, where metallurgist GEORGE OSWALD showed me a bewildering variety of interesting things, old, current and in prospect. His card index file specifying the heat treatment of 20,000 active parts is impressive in itself; the prize exhibit is a spring punched from sheet that requires ten treatments to give it spring temper at correct places and hard spots at others where slight wear occurs. Much pot carburizing is done in a department a model for cleanliness; many small flat gears requiring tolerances measured in ten-thousandths are made from nitralloy and nitrided; other flat levers needing very thin cases are of carbon steel, treated at low temperature in "Ni-carb" (a gas with active carbon and nitrogen compounds) and not quenched. What the men call the "world's fastest carburizer" was hardening the tip ends of the teeth on a forked rack punched from full-hard, cold-rolled strip; all the part except the teeth is in a water bath and a 20-sec. traverse of three small acetylene-rich flames in tandem followed by a water jet gives them file hardness on their ends. Many, many sub-assemblies of small parts are made by copper brazing. Decarburization and softening of hardened items is avoided by drying bone-dry the pre-formed and enriched gas atmosphere, by means of activated alumina.

***Kinks About Copper Brazing***

(Here are some other kinks about brazing learned at "Cash" and elsewhere which may be new and useful: The spread of copper over steel surfaces may be stopped by a chalk mark or by painting with an emulsion of powdered chalk. . . . . Powdered copper — or copper oxide — suspended in a slow drying lacquer may be easier for the operator to daub on than it is for him to fasten copper wires at the proper place, and is just as effective. . . . . Proper centering of round pellets of tungsten or other contact points on flat steel parts may be automatic — merely raise a tiny teat on the steel surface at the exact center required for the pellet, get the pellet somewhere near the correct position, and the capillary action of the liquid copper will center it exactly. . . . . Monel to 18-8 is a difficult joint to braze because surface oxide is not easily reduced by the usual atmosphere of hydrogen, so keep the atmosphere *dry* and use alcohol as a vehicle for the copper oxide paint — it also acts as a flux. . . . . Anybody know any more?)

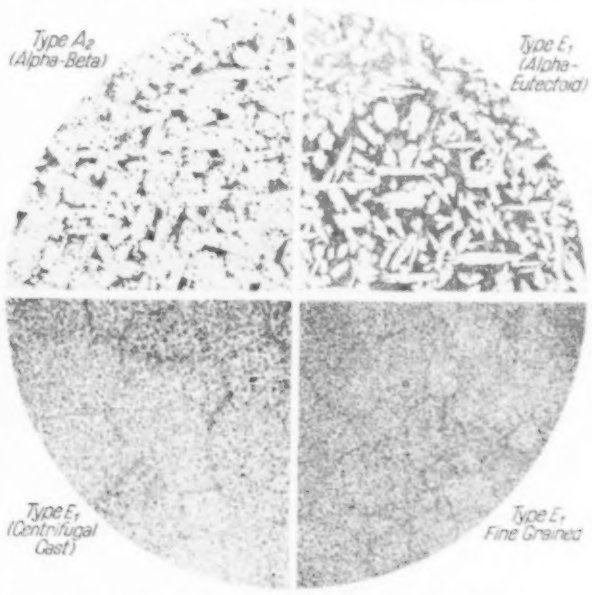
TO CINCINNATI, Queen City of machine tools and breweries, and was shown operations at Cincinnati Milling Machine Co. by STANLEY BINNS, metallurgist, and GEORGE GERDES, planning engineer. There is a large battery of pit furnaces wherein shafts, arbors, sleeves and strings of symmetrical parts are hung, vertically, for heating and quenching. All these furnaces have fan-circulated atmospheres, and BINNS emphasizes the value of this means for uniform heating as an important factor in minimizing warpage. Such minor straightening of long parts as is necessary is done hot — it is easier, does no damage from locked-up stresses, and the part "stays put". GERDES told me of their recent delays in getting long hydraulic cylinders for the operation of the tables on their grinding machines; these cylinders may be 10 ft. long and up to 2½-in. internal diameter, and of roundness and straightness so true that they must be hollow bored — a gun making operation. Right now everyone who can make such cylinders is busy boring guns, so we have the anomalous situation where tools necessary for more munitions are held up by munition manufacture! Since pressures in these cylinders are moderate it was thought that seamless tubes would serve, but cold-drawn tubes are so full of locked-up stresses that any machining on inside or outside surface warps them hopelessly. Fortunately one of the leading tube companies, by extra care and high quality carboloy dies, has been able to deliver tubes that meet all tolerances as to internal dimension — truly a remarkable feat. . . . . Piston rods also posed a problem; they are equally long, much smaller, and must have an axial oil duct. Their *exterior* must be round and straight with lap finish. They are now made of S.A.E. 4140 or 1040 seamless tubing, quenched and tempered to relieve internal stresses and improve machinability, and finished into a true cylinder by a succession of straightenings and grindings and a final lapping on centerless machines.

***Cold-Drawn Tubing for Hollow Bored Cylinders***

# Controlled Aluminum Bronze *for* Aircraft Parts

By George K. Dreher
Plant Manager, Ampco Metal, Inc.
Milwaukee, Wis.

*Type $A_2$ and $E_1$ (Respectively Alloy IV and V of Data Sheet) Cast in Sand, Showing the Difference of Minor Composition Changes Permissible in Most Specifications, and Which Result in Notable Differences in Physical Character and Applications*




*Same Alloy V Centrifugally Cast, and the Grain Refinement (About One-Quarter) in Shadowy Primary Structure and Granular Secondary Structure Obtainable by the Proper Modifying Agent. Research in this field has only begun. Enlarged 50 X*

Copper-aluminum-iron alloys or "aluminum bronzes" were introduced to industry in 1870 as "just another bronze". Consequently, this series of alloys was accorded, at the time, the same technique in manufacture as was applied to standard bronze compositions, and these uncontrolled methods of the earlier days accounted for the failure of aluminum bronzes to establish a trustworthy reputation. A different type of production or a vastly better foundry control was necessary to bring out their latent service qualities, and in the last 20 years the increasing application of scientific metallurgical methods brought about this required perfection and control. Aluminum bronzes have thereby successfully competed with an unbelievable number of common and special bronzes, including precipitation hardening non-ferrous alloys, carbon steels, and alloy steels, for use as vital propeller, engine, and landing gear parts in commercial and military aircraft. All major fighting and bombing craft produced in this country are now equipped with several components made of aluminum bronze.

The control of these alloys to achieve desired results follows the path laid down by steel metallurgists in the production of their alloys. After all, there is no common sense in assuming that bronzes can be loosely composed when the analysis of steel must be held to 0.10 or 0.01% in order to duplicate results. By applying some of the technique of the steel makers, the producers of aluminum bronze have been able to alter that practice to suit their problem, and have come up with results analogous to those expected of the most advanced steel and iron castings and rolled products.

Composition, or chemical control of the aluminum, is just as important in copper alloys as is the proper control of carbon in iron alloys. The thermal diagram, or the Cu-Al equilibrium diagram on page 790, very clearly reveals the structural variations which are possible with minor changes in aluminum content in the vicinity of 10% aluminum, around which are grouped the most widely used compositions. The upper micros on this page clearly illustrate this difference. A variation of 0.2% aluminum can change the left into the right-hand structure, yet many specifications covering aluminum bronze permit variations in composition up to 2%! Small wonder, then, that inconsistent results were customary. Utmost caution in the

composition of the furnace charge will not alone give the required effect. Rigidly correct operating practice and constant laboratory supervision to maintain proper chemical balance, combined with closely supervised melting practice, are precepts of this phase of control.

### *Microstructure*

Some remarks about the interpretation of the microstructures may not be amiss at this moment, although it is set in a somewhat smaller type and can be skipped if the reader is in a hurry. All of the micros are etched with ferric chloride (which leaves the alpha particles bright). The comparative lack of coring is due, in part, to the narrow range between liquidus (completely liquid) and solidus (completely solid) in all this alloy system. As a matter of fact the coring that does occur is responsible for a desirable heterogeneous structure in commercial alloys.

An alloy like $A_1$ (Fig. 2) containing 7% aluminum would have a single phase structure characteristic of pure copper, since the aluminum enters into solid solution in the copper; the crystal structure of the alpha phase is the same as copper — namely, face-centered cubic — and the aluminum progressively strengthens the tough and ductile copper. An alloy like $A_2$ (Fig. 2) containing 9% aluminum should, if sufficiently slowly cooled, also reach an equilibrium consisting of alpha solid solution only. As shown by the micro on p. 789, this is not achieved in commercial practice, even though the reaction rates and diffusion constants in these alloys are quite high. Alloy $A_2$ would solidify at about 1890° F. into pure $\beta$ solid solution, but on cooling the $\beta$ solution would immediately start transforming into alpha. Time at temperature does not permit this reaction to become complete, however, and the residue of $\beta$, the dark-etching areas at the grain boundaries, is shot through with tiny particles of alpha, as well as small portions of eutectoid, either due to the residual $\beta$ transforming into $\alpha$ plus eutectoid, or due to segregated high aluminum portions of the alloy formed by coring during solidification.

$\beta$ solid solution, by the way, is very unstable; it cannot be completely preserved in the alloys by any practicable rate of cooling. It is known to be of body-centered cubic crystallinity; this atomic arrangement, being the same as that of ferrite, is also associated with strength, toughness and hot workability.

Alloy $E_1$ solidifies as beta but starts changing to alpha at about 1550° F. About half of it has transformed by the time the metal has cooled to 1058° F. and thereupon the remainder transforms more or less completely into a fine mixture of alpha and delta crystals (Fig. 1). An analogy exists between these bronzes containing 9.5 to 16%

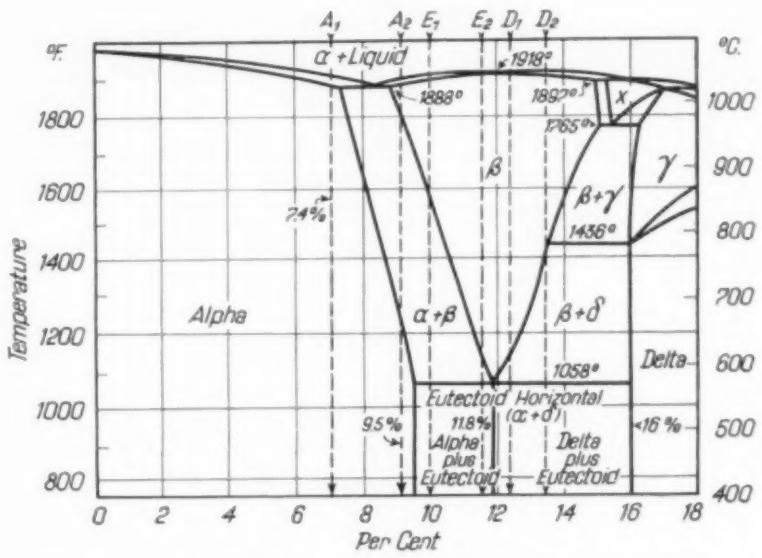
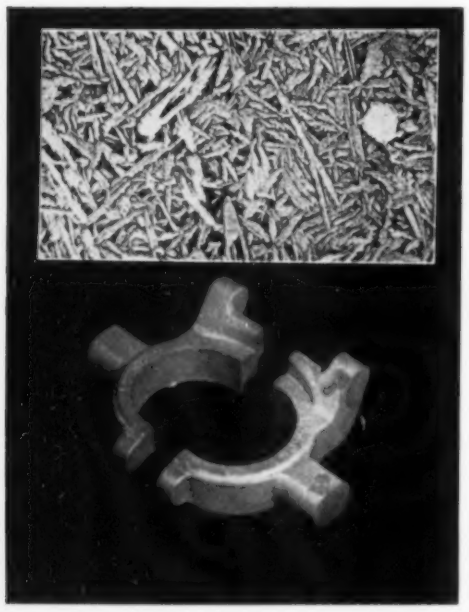



*Fig. 2 — Copper-Aluminum Equilibrium Diagram According to Jennison and Smith (Metals Handbook) on Which Has Been Noted Location of Equivalent Structures of Commercial Aluminum Bronzes Described Herein. The relatively steep phase boundaries indicate the need for close control of chemistry and cooling rates if a uniform product is to be secured*

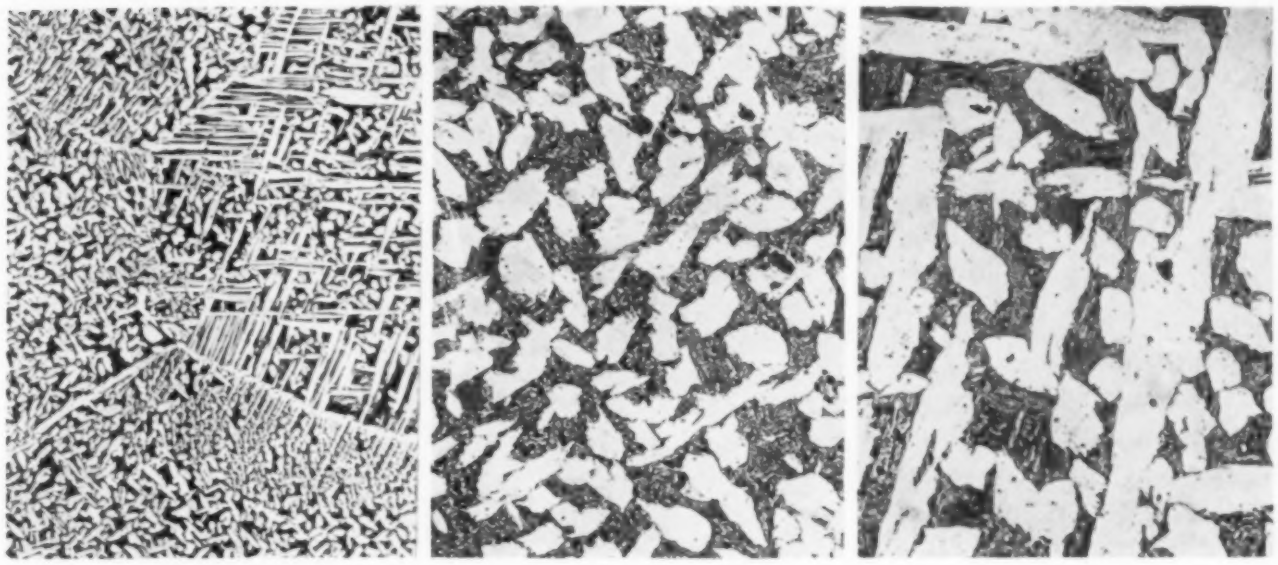
aluminum and the steels; $\beta$ solid solution corresponds to austenite and the $\alpha+\delta$ eutectoid corresponds to pearlite. Quenched $\beta$ has an acicular structure which looks like martensite and is hard and strong. In fact, the heat treatment of aluminum bronzes can be rationalized by analogies to the heat treatment of carbon steels.

Delta solid solution has a complex cubic structure and is hard and brittle. It cannot be readily identified under the microscope, so the interpretation of many micros is obscure. In general, rapid chilling of $\beta$ will give an acicular or martensitic appearance; more leisurely reaction of $\beta$, as well as cooling to below the eutectoid, will produce a mottled, more irregular granular appearance. Sometimes a distinctly pearlitic structure will be produced, as will be illustrated later. However, the physical properties of a casting containing well-developed delta constituent leave no doubt



*Tail Wheel Trunnion Yokes. Alloy I, sand cast, heat treated and X-rayed*

*Fig. 3 — Effect of Cooling Rate (or Size of Casting) on Structure of 10.5% Aluminum, 1.0% Iron Alloy (No. II of Data Sheet). All castings were made from same ladle of metal*



| | Chill Cast ⅞-In. Bar | Ear of Chilled Test Block | Ear of Sand Cast Test Block |
|---|---|---|---|
| Tensile strength | 90,000 psi. | 75,000 psi. | 60,000 psi. |
| Yield strength | 40,000 psi. | 37,000 psi. | 43,000 psi. |
| Elongation | 15% | 12% | 8% |
| Brinell hardness | 140 | 140 | 160 |

as to its presence; the alloy is considerably harder without being stronger, and the ductility as measured by elongation in the tensile test is sharply reduced.

### *Grain Refining and Alloying*

Aluminum addition to molten steel as a degasifying and a grain refining agent is a comparatively recent development, but finds its counterpart in the use of some elements for the same action in aluminum bronze. In steel the aluminum reduces compounds of iron to compounds of aluminum; in aluminum bronze, the task is to reduce compounds of aluminum and retain metallic purity. Very few elements are capable of doing this. Prudence is required; one part in 8000 of some active deoxidizers is enough to treat and refine the particle size, whereas twice as much will definitely ruin the metal by causing grain boundary segregation. Lower micros on page 789 illustrate this proper refining effect. Some of the more common elements have a similar effect upon aluminum bronze, although they must be used in higher proportions than the above. Iron is the most widely used metal for refining the grain size, although nickel, manganese, and zinc each have an effect in varying degrees.

The actual method of composing an alloy in the melting crucible often determines the action of these metals on the final constituents. Most of the elements mentioned above have what is termed a "negative replacement effect" upon the aluminum content. Thus, 1% of iron will normally effect a 0.05 to 0.12% displacement; this means that if a 10% aluminum alloy carries 3% of iron, its approximate location on the equilibrium diagram would be where a 9.65% aluminum alloy free of iron would fall. In other words, iron has the effect of moving the phase boundaries to the left. It is possible to compose or formulate an alpha-eutectoid type of alloy and evolve an alpha-beta type, provided the iron was properly alloyed with the basic elements. Special methods of compounding seem to enhance this effect, even up to a 0.40% aluminum displacement for each 1% of iron. Under such conditions in a 10% aluminum alloy with 3% iron, a shift of the phase boundaries toward the left about 1.20% is possible. Granted that the chemical composition has been made up with the utmost care, one can readily understand why such inconsistent results are obtainable with variations in compounding and melting practice.

Progressing from chemical composition to the next control step, we again follow steel metallurgical practice. Properly designed molds or chills are essential for the desired

*Cam Support; Forged of Alloy I. Structures in this and similar views at 75 dia.*

structure in aluminum bronze castings as well as in iron and steel. While many foundry methods in both metals are similar, the structures sought for are decidedly in contrast. Aircraft requirements demand consistent duplication of structure to insure uniform manufacturing and service records, and Fig. 3 at top page 791 demonstrates the range in which a given alloy can be controlled in ordinary casting. The left-hand view represents a drastically chilled metal — rarely called for, although approximately this structure will be found in a ⅛-in. section in a small casting. The original beta crystals have precipitated alpha along their crystallographic planes and a quasi-martensitic or Widmanstätten microstructure results. The middle is from a chilled ear from a 50-lb. U. S. Navy test block; the third is the result of casting the same in ordinary sand. In this case cooling has been so slow that the alpha solid solution rejected at high temperature has grown into large slabs, and the remaining beta has changed into pretty well defined (even lamellar) eutectoid of alpha plus delta when passing the 1058° critical point. This latter structure calls for heat treatment to retrieve the constituents and the properties of the middle view.

Sand and chilled castings for aircraft are necessarily small and light-sectioned wherever practical. The physical properties of these castings are shown in the Data Sheet, page 797. Ultimate tensile in chilled specimens in the alpha and low eutectoid ranges (alloy types $A_1$, $A_2$ and $E_1$ in Fig. 2) is usually high, with yield strength of approximately one-half the ultimate, good elongation, low proportional limit, and relatively tough impact properties. As the cooling time after pouring is extended, these properties tend to invert until a tensile strength of approximately two-thirds the chilled specimen is reached.

The result of extremely long cooling is illustrated in Fig. 4. Here a delta type alloy at 500 magnifications is contrasted with the same alloy after a 15-hr. cooling cycle. In the corner of the second micrograph can be seen a lamellar eutectoid formation similar to pearlite in steel. This tendency, often erroneously called "self-annealing", is present in all eutectoid-bearing aluminum bronzes. When fully developed, the metal has reached its stable structure, yet is inferior as an engineering material because of its tendency towards flaking and galling under service loads. Well developed alpha plus eutectoid ("self-annealing") in large castings can lower tensile strength from an expected 85,000 psi. to a quite inadequate 52,000. The globular or sorbitic "pearlite" structure shown at the left in Fig. 4 represents the desired eutectoid for aluminum bronze. Careful control of the time between pouring and shake-out will assist materially in getting this structure; similarly, molten metal temperatures play an important part in procuring the desired constituents.

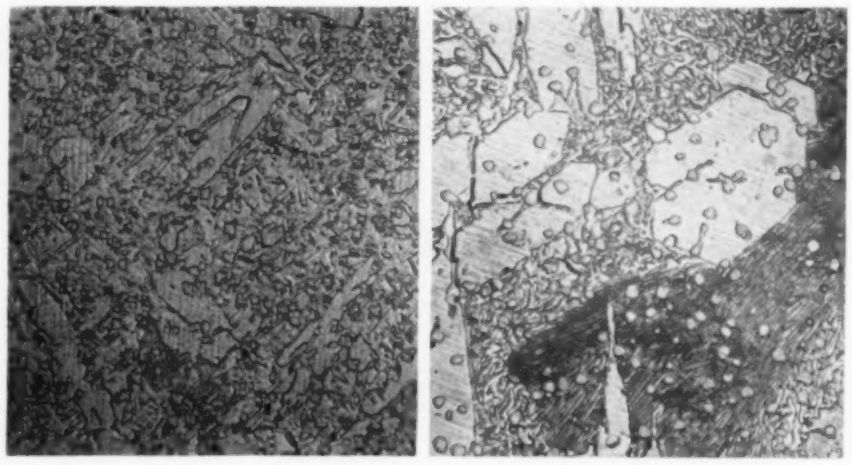


*Fig. 4 — Alloy VI of the Data Sheet, Sand Cast at Left Versus 15 Hr. From Pour to 400°F. Note the increased grain and particle size, as well as the formation of an undesirable lamellar eutectoid. Etched with ammonium hydroxide plus peroxide, and magnified 500 diameters*

Centrifugal casting is used wherever possible for aircraft parts. By pouring in a high speed revolving mold, a pressure of 66 psi. on the molten metal is ordinarily achieved in contrast to 1.62 psi. in similar sand castings. This enormous increase in pressure aids in eliminating gases and low gravity particles from the parent metal. The resultant increase in density

also increases service life. Rapid cooling produces a desirable heterogeneous structure in much larger castings than would be possible in sand molds or chills. Figure 5 compares the structure of sand and centrifugal products, and the half tones on pages 794 and 795 illustrate the centrifugal casting operation.

### *Hot Work and Heat Treatment*

Further structural control is achieved by hot working and heat treatment, or a combination of these processes. The micrographs in Fig. 6, page 796, show the results of rolling, forging or extruding some representative alloys.

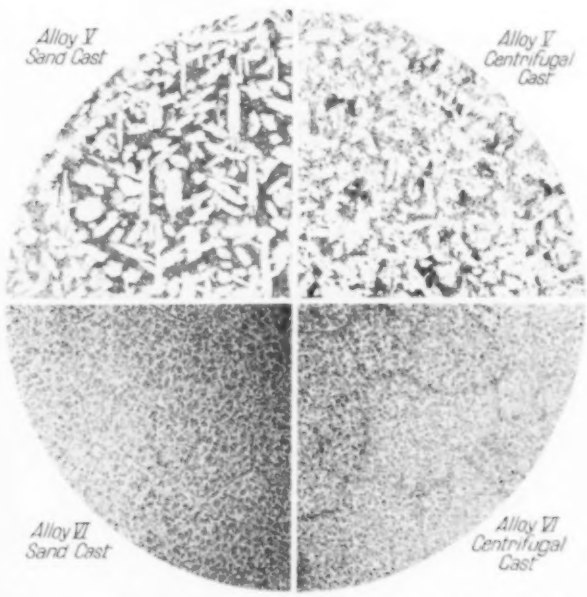
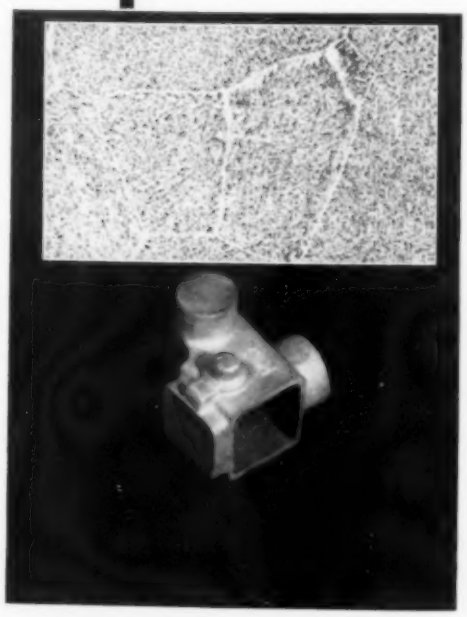
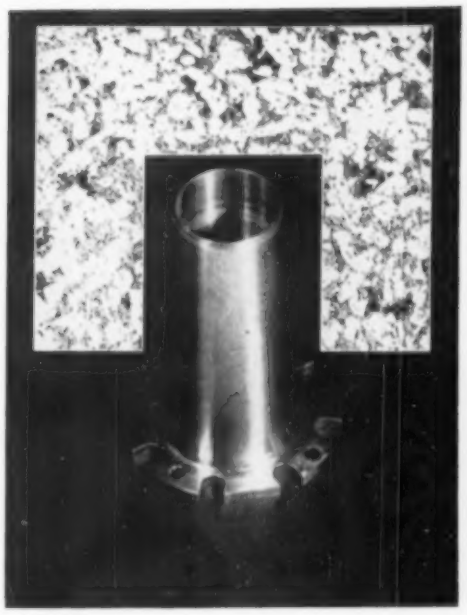



*Fig. 5 — Representative Structures of Castings Sand Cast and Centrifugal Cast. For compositions, properties and uses see the Data Sheet, page 797*

Virtually all compositions of aluminum bronze can be rolled, if proper attention is given to temperatures at which the metal is worked, although the rolled shapes ordinarily have lower aluminum than castings. As the aluminum content increases, so does the tendency to crack at heats below 1150° F.



*Gun Bracket. Alloy V, sand cast, heat treated and X-rayed*

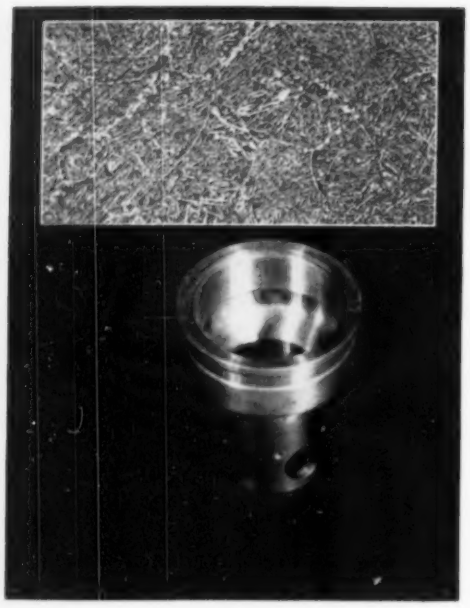


*Propeller Blade Bushing. Centrifugal casting of Alloy V*

The alpha series of alloys will permit the severest cold working if frequently annealed to relieve internal stresses. All the alloys can be extruded, although only the alpha and low eutectoid compositions can be satisfactorily straightened thereafter. Although these low alloys could be centrifugally cast for comparable physical characteristics, the directional grain of extruded and rolled products is desirable for some applications, particularly where grain size and weight is a factor. Worked metals may be designed for a safety factor of 1.2 figured on the proportional limit, whereas castings require a safety factor of 2.4 in the existing Army Air Corps specifications. Low aluminum alloys develop optimum physical characteristics in the worked state, and annealing heat treatments are only used to relieve stresses. Higher temperatures, to alter the structure, are only used in some parts.

Heat treatment is defined by WEBSTER as the heating and cooling of metals to achieve a predesired result. To achieve the ultimate structure for service, it is frequently necessary to heat large aluminum bronze castings to a calculated point above the eutectoid temperature; then control the cooling to approximate that of the chilled naval test block in Fig. 3 and thus get comparable results. The maximum temperature must be watched to prevent, as far as possible, any loss of complexity in the structure. High reheating temperatures will rapidly homogenize the crystals, and the resulting structure is not so desirable in some services involving wear.

Low temperature stress relieving of forgings and rolled products for aircraft requirements is customary. This is particularly true of engine components. These operations are generally carried out on symmetrical shapes after surface tensions have been relieved by a roughing machine cut. Heat treatment (quench and draw) of aluminum bronze has served to meet many requirements for maximum strength in parts for propellers, engines, and fuselage units. The most sensational increase in test



*Propeller Locking Nut. Alloy V, centrifugal cast and heat treated*

figures through heat treatment is in the proportional limit. Those bronzes that are capable of being heat treated to ultimate strengths above 100,000 psi. also have their proportional limits increased nearly 100% over that of the cast state. Inasmuch as this figure is most important in aeronautical design, it permits a great reduction in weight over parts as cast.

### *Typical Aircraft Parts*

Aluminum bronzes for aircraft requirements can be divided into two groups. First is the sand cast, chill cast, centrifugally cast, and extruded alloys of heterogeneous structure used primarily for wear resistant and vibration-dampening qualities. Second is the rolled, forged or heat treated materials for assembly components where high proportional limits and maximum strengths are desired. Six good examples of these parts are shown on these pages.

Outstanding in the first group are the blade bushings for hydraulic controllable pitch propellers illustrated on page 793. In four years of service, there has been no failure in service and no bushing has actually worn out. The propeller manufacturer has established a life expectancy of 2000 hr. for this part which, by experience, has proved capable of considerably longer service. These bushings were formerly made of beryllium copper at more than triple the cost and less than half the service life now allowed. Even this life was not met in many instances. Private flyers rarely replace these aluminum bronze parts, made of $E_1$ alloy No. V, except at major overhauls of the propeller assembly. Practically all available types of steel and bronze were tried before this problem was solved.

Another part of this propeller assembly is the cam-actuating roller which varies the pitch of the full-feathering type of propeller (see the illustration on page 795). This roller is made of a delta type alloy, $D_2$ of Fig. 2. and replaces hardened steel. In both bushing and roller the anti-seizing, longer-wearing properties of a bronze in comparison with steel, plus its good physical properties and high fatigue resistance, make possible the intricate mechanism of modern propeller designs demanded by military requirements.

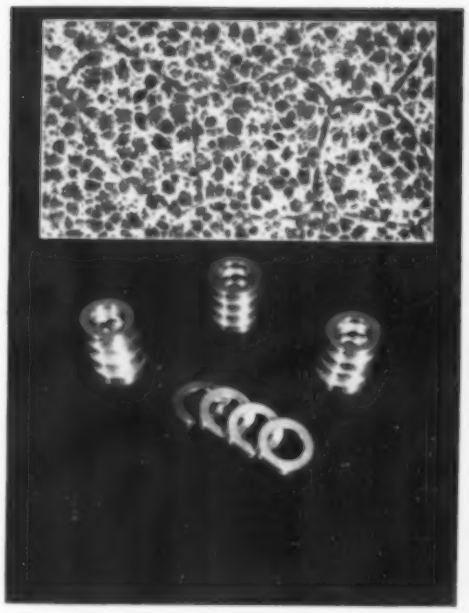
The mention of fatigue resistance also calls to mind the vibration damping properties of the alpha type aluminum bronzes. Although this characteristic is present in all alpha and eutectoid alloys of this series, a really remarkable performance is recorded by a high iron composition of $A_2$ microstructure used as a damping bushing between the propeller assembly and the main crankshaft of an airplane engine. This serves to lengthen materially the life of the engine itself by eliminating the excessive vibration customarily transmitted to the engine from the propeller.

*Pouring and spinning an aluminum bronze bushing by the centrifugal process. Self purging of im-*

Electrically operated variable pitch propellers are held onto the crankshaft by a heat treated aluminum bronze locking nut shown on page 794. Hardened steel locking nuts were formerly used, but they did exhibit a tendency to seize the shaft of the motor, thereby delaying the overhaul, and sometimes loss of the crankshaft itself when the two could not be separated.

After some exhaustive tests with various types of alloys, this aluminum bronze was found to meet all requirements. In actual service, these parts are subject to the vibrations of the propeller and motor unit. The severest strain is in locking this nut onto the crank shaft and up against the propeller housing. A 1-in. round steel bar is inserted through two holes in the skirt, and used as a wrench to lock the nut in final position through the application of a 1000-ft-lb. torque.

The view on page 792 shows a motor part made of aluminum bronze. Fatigue resistance



*Propeller Cam Rollers. Extruded Alloy VI*

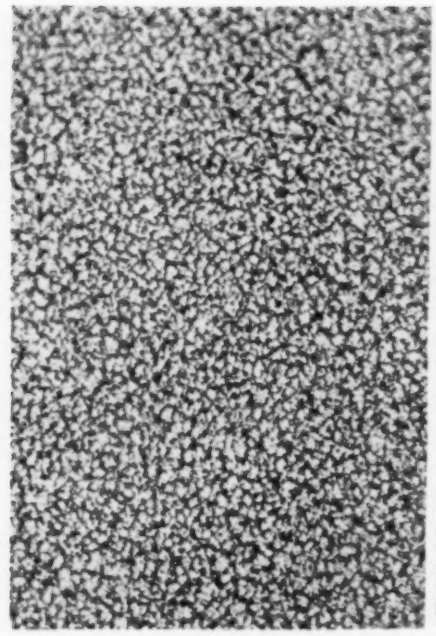
and wear resistance play an important part in these motor installations. A third factor of considerable note in aircraft design is the light weight of this high strength material. Weighing only 0.27 lb. per cu.in. on the average, it is considerably lighter than other non-ferrous alloys, being roughly 20% lighter than tin bronzes and some 6 to 12% lighter than manganese bronzes.

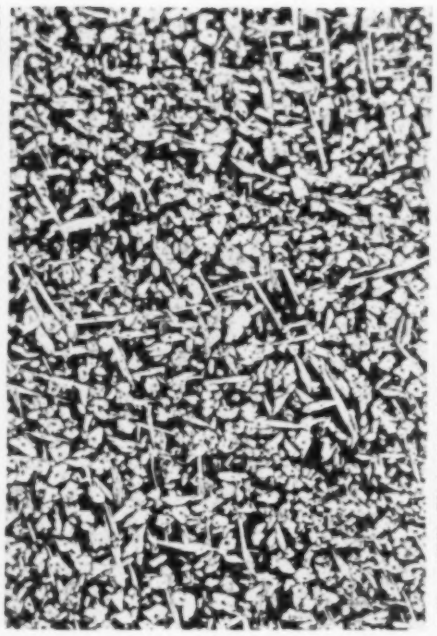
This light weight, plus its high proportional limit in the heat treated state, makes aluminum bronze desirable for important components designed on a strength-weight basis in modern bombing and fighting planes. The view on page 793 shows a gun bracket which acts as a pivot around which the gun housings of certain bombers are designed. The entire machine gun mechanism as well as the airman operating it are held in place by this little casting. Its failure would mean the loss of the gun, man, and probably the plane, if a rival fighter craft discovered that defenseless point. These castings, as well as the tail wheel trunnion support shown on page 790, are thoroughly X-rayed to detect minor flaws which may exist now and then.

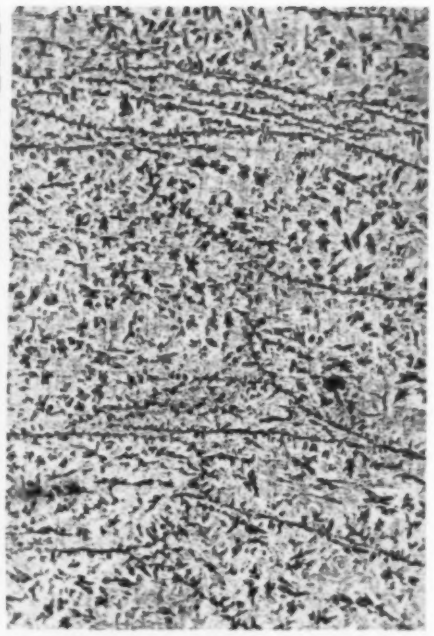
X-ray inspection is practiced by a few manufacturers on aircraft castings other than those made by the centrifugal process. The density and unquestionable soundness of castings made by the centrifugal method have made this practice unnecessary in such parts.

The aluminum bronze industry is proud of its contribution to the aerial defense of our country. This pride is doubly justified through the fact that American-built planes are consistently showing better performance than those produced by other nations. It seems safe to say and reasonable to assume that the advanced aluminum bronze alloys used by manufacturers of American aircraft and engines may be given credit for at least a mentionable part of this superiority.

*purities from inner bore by combination overflow and 66-psi. pressure is demonstrated in view below*







Rolled

Rolled-Alloy V

Rolled

Cross Sections
of
Worked Aluminum Bronzes
at 100 Diameters

See data sheet, page 797
for physical properties

Extruded

Alloy IV

Alloy VI

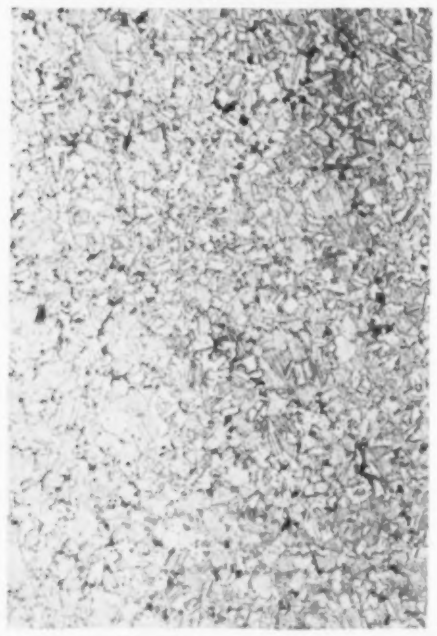
Extruded

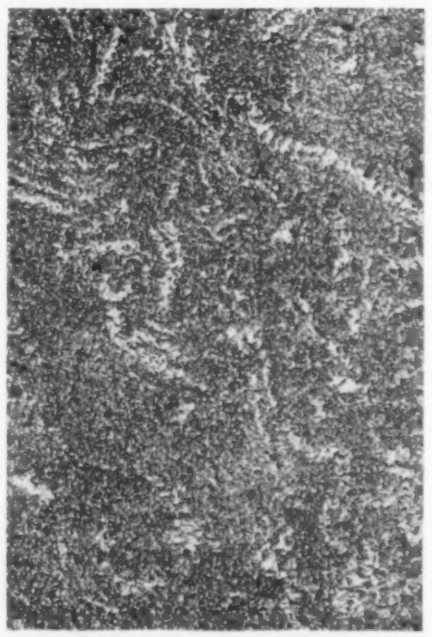
Note twin bands, a characteristic of dilute or worked alpha phase alloys

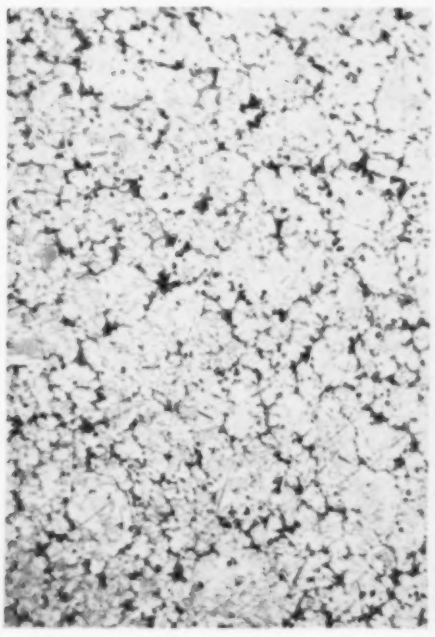
Forged

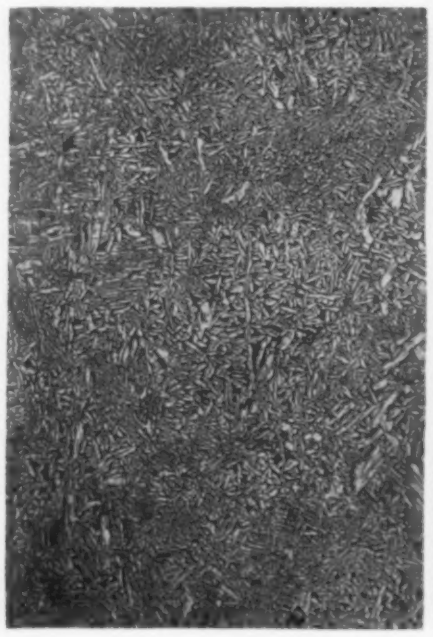
Forged

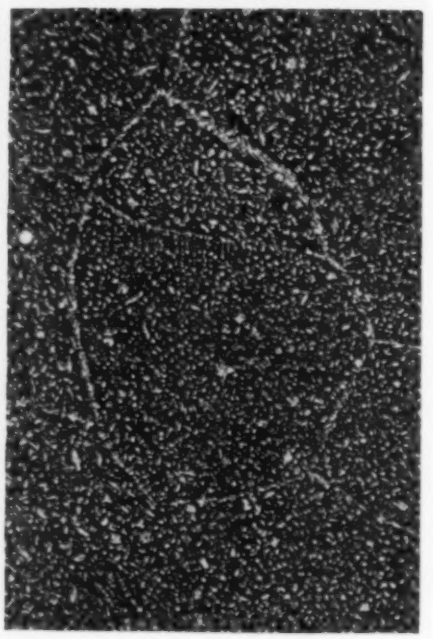
Forged-Alloy I











# ALUMINUM BRONZES COMMONLY USED IN AIRCRAFT

Compiled by W. W. Edens, Ampco Metal Inc.

| Reference Number and Nominal Composition[a] | Condition | Specification Met | Tensile Strength, Psi. | Yield Strength, Psi. | Proportional Limit, Psi. | Elongation in 2 in., % | Reduction of Area, % | Brinell Hardness, (3000 kg) | Impact | | Endurance Limit, Psi.[b] | Compression Tests | | Lb. per Cu. In. | Representative Uses in Aircraft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Izod Ft.-lb. | Charpy Ft.-lb. | | Elastic Limit Psi. | Ultimate Psi. | | |
| Alloy I. 89.5 % Cu 9.5 % Al 1.0 % Fe Structure $A_2$ | Sand Cast | PWA-135 | 70 000<br>75 000 | 25 000<br>32 000 | 12 000 | 30<br>40 | 30<br>40 | 115<br>126 | 32<br>38 | 26<br>30 | In Test | 25 000 | In Test | 0.270 | Bushings; Gears |
| | Centrifugal Cast | | 77 000<br>82 000 | 27 000<br>34 000 | 14 000 | 25<br>30 | 25<br>30 | 121<br>134 | | | | | | | Bushings; Gears |
| | Heat Treated | QQB-671 Grade "B" | 78 000<br>88 000 | 38 000<br>48 000 | 22 000 | 22<br>30 | 24<br>32 | 143<br>156 | 25<br>30 | 17<br>24 | In Test | 35 000 | In Test | 0.270 | 1. Gun Bearings 2. Gun Mountings 3. Tail Wheel Bushings 4. Landing Gear Nuts 5. Tail Wheel Trunnion Yokes |
| | Forged | | 75 000<br>80 000 | 26 000<br>30 000 | | 30<br>35 | 20<br>25 | 121<br>134 | | | | | | 0.270 | 1. Motor Parts 2. Bearing Liners 3. Cam Supports 4. Thrust Pads 5. Retainer Plates |
| Alloy II. 88.5 % Cu 10.5 % Al 1.0 % Fe Structure $E_1$ | Sand Cast | | 70 000<br>80 000 | 38 000<br>45 000 | 15 000 | 12<br>20 | 14<br>20 | 131<br>143 | 28<br>34 | 20<br>26 | In Test | 30 000 | In Test | 0.270 | 1. Bushings 2. Gears 3. Corrosion Resistance |
| | Centrifugal Cast | | 77 000<br>85 000 | 40 000<br>47 000 | 16 000 | 10<br>16 | 10<br>16 | 137<br>153 | | | | | | | Bushings; Gears |
| | Heat Treated | | 80 000<br>95 000 | 42 000<br>50 000 | 30 000 | 12<br>15 | 13<br>17 | 163<br>179 | 25<br>30 | 15<br>20 | In Test | 45 000 | In Test | 0.270 | 1. Idler Gear Bushings 2. Blade Bushings 3. Master Rod Bushings |
| Alloy III. 88.5 % Cu 8.6 % Al 2.9 % Fe Structure $A_1$ | Sand Cast | 46B-18C QQB-671 "A" | 60 000<br>70 000 | 22 000<br>27 000 | 14 000 | 22<br>27 | 22<br>27 | 109<br>124 | 75 | 60 | In Test | 18 000 | 119 200 | 0.279 | 1. Tail Wheel Bearings 2. Landing Gear Control Bearings 3. Gun Slides 4. Gun Mountings |
| | Centrifugal Cast | | 70 000<br>77 000 | 27 000<br>34 000 | 14 000 | 25<br>30 | 25<br>30 | 116<br>131 | | | | | | | Bushings for Tail Wheel Strut and Landing Gear Control |
| | Forged | 46B-17b "B" QQB-666 "B" | 82 000<br>90 000 | 52 000<br>38 000 | | 25<br>30 | 25<br>30 | 143<br>156 | | | | | | 0.270 | |
| | Extruded | 46B-17b "B" QQB-666 "B" | 88 000<br>94 000 | 48 000<br>55 000 | | 25<br>30 | 30<br>40 | 179<br>187 | | | | 58 000 | | 0.270 | |
| | Hot Rolled | 46B-17b "B" QQB-666 "B" | 95 000<br>105 000 | 55 000<br>65 000 | | 18<br>22 | 20<br>25 | 170<br>182 | | | | 48 000 | | 0.270 | |
| Alloy IV. 86.5 % Cu 10.2 % Al 3.3 % Fe Structure $A_2$[c] | Sand Cast | | 70 000<br>80 000 | 32 000<br>37 000 | 16 000 | 18<br>22 | 16<br>20 | 131<br>156 | 35 | 28 | | 22 000 | 124 600 | 0.275 | 1. Bushings 2. Gears 3. Tail Wheel Strut and Landing Gear Control Bearings 4. Valves Guides 5. Pump Bodies |
| | Centrifugal Cast | | 77 000<br>85 000 | 35 000<br>40 000 | 17 000 | 15<br>20 | 15<br>20 | 137<br>160 | | | | | | | 1. Bushings 2. Gears 3. Shock Absorber Piston Bearings 4. Tail Wheel Strut Bearings 5. Landing Gears 6. Packing Nuts 7. Tail Wheel Packing Nuts 8. Orifice Retainers |
| | Forged | | 87 000<br>95 000 | 35 000<br>40 000 | | 25<br>30 | 25<br>30 | 150<br>156 | | | | | | | 1. Landing Gear Shock Absorber Pistons 2. Piston Bearings 3. Gears 4. Packing Nuts |
| Alloy V. 85.0 % Cu 11.0 % Al 3.7 % Fe 0.3 % Others Structure $E_1$ | Sand Cast | | 77 000<br>85 000 | 35 000<br>42 000 | 18 500 | 10<br>14 | 6<br>10 | 159<br>183 | 25 | 17 | 25 000 | 30 000 | 136 430 | 0.273 | 1. Wear Plates 2. Hinge Plates 3. Control Gears 4. Valve Seats 5. Pump Bodies |
| | Centrifugal Cast | PWA-241 | 82 000<br>90 000 | 38 000<br>44 000 | 19 000 | 8<br>12 | 6<br>10 | 166<br>187 | | | | | | | 1. Blade Bushings for Electric, Hydrometic and Controllable Pitch Propellers 2. Propeller Hub Nuts 3. Propeller Rear Cone Bearings 4. Pump Parts |
| | Heat Treated | Curtiss 3300 | 95 000<br>105 000 | 43 000<br>50 000 | 31 000 | 10<br>15 | 12<br>18 | 179<br>207 | 15<br>20 | 20<br>25 | 35 000 | 45 000 | 150 000 | 0.274 | 1. Landing Gear 2. Tail Wheel and Strut Bushings 3. Retracting and Packing Nuts 4. Orifice Retainers 5. Wear Plates 6. Propeller Hub Nuts 7. Front and Rear Propeller Cone Bearings |
| | Heat Treated | Air Corps 11075 | 90 000<br>100 000 | 45 000<br>55 000 | 34 000 | 3<br>7 | 3<br>7 | 202<br>223 | 18<br>22 | 11<br>15 | In Test | 50 000 | 155 000 | 0.274 | |
| Alloy VI. 82.5 % Cu 13.2 % Al 4.3 % Fe Structure $D_1$ | Sand Cast | | 70 000<br>80 000 | 42 000<br>Min. | In Test | 1<br>4 | 0<br>4 | 285<br>311 | 10 | 6<br>7 | In Test | 50 000 | 160 000 | 0.258 | 1. Drawing and Forming Dies for Carburetor 2. Fuselage and Other Stainless Steel and Aluminum Parts |
| | Centrifugal Cast | | 70 000<br>80 000 | 42 000<br>Min. | In Test | 1<br>4 | 0<br>4 | 285<br>311 | 10 | 6<br>7 | In Test | 50 000 | 160 000 | 0.258 | Dies |
| Alloy VII. 81.4 % Cu 14.1 % Al 4.5 % Fe Structure $D_2$ | Sand Cast | | 75 000<br>85 000 | 45 000<br>Min. | In Test | 0<br>2 | 0<br>2 | 321<br>352 | 8 | 4 | In Test | 65 000 | 171 000 | 0.257 | Drawing and Forming Dies |
| | Centrifugal Cast | | 75 000<br>85 000 | 45 000<br>Min. | In Test | 0<br>2 | 0<br>2 | 321<br>352 | 8 | 4 | In Test | 65 000 | 171 000 | 0.257 | 1. Hydromatic Propeller Cam Rollers 2. Dies |
| Alloy VIII. 81.3 % Cu 10.7 % Al 4.0 % Fe 4.0 % Ni Structure $A_2$ | Extruded | HSP-22 | 80 000<br>90 000 | 50 000<br>Min. | In Test | 1<br>2 | 1<br>2 | 321<br>358 | | | | | | 0.257 | Cam Rollers |
| | Forged and Heat Treated | [d] HSP-18 | 96 000<br>102 000 | 55 000<br>60 000 | 30 000 | 10<br>15 | 10<br>15 | 190<br>217 | 15<br>20 | 25<br>30 | | | | 0.280 | Propeller Locking Nuts |
| | Heat Treated | Wright 6852-A | 90 000<br>96 000 | 42 000<br>50 000 | 27 000 | 8<br>12 | 8<br>12 | 217<br>229 | 10<br>15 | 20<br>25 | | | | 0.280 | |

Note: (a) Microstructure correlates with marked line on equilibrium diagram, page 789

(b) Based on 100 000 000 cycles of stress

(c) Uses for Alloy IV: Extruded shapes: 1. Landing gear torque arm bushings 2. Landing gear and strut bushings and parts
Rolled rod and sheet: 1. Windshield wiper parts 2. Landing gear and strut bushings and parts 3. Wear plates 4. Defroster parts

(d) Aluminum is 10.3 %

# MORE STRENGTH TO MEET STRESS...

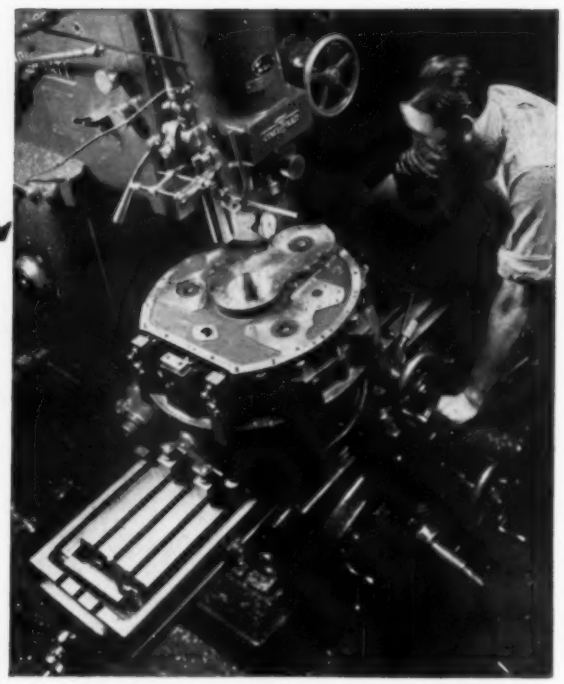
**50** *places in a power shovel...*

**85** *places in a rock drill...*

**275** *places in a milling machine*

# NICKEL ALLOY STEELS

Measured by weight, nearly ⅓ of this Bay City power shovel is fabricated from long-wearing Nickel alloy steels. 50 vital parts which must withstand fatigue strains, shock stress and overloads are made of SAE 3135 oil quenched Nickel-chromium steel and other Nickel alloy steels. Frames and bases are Nickel cast steel. "Chabelco" crawler drive chains, Diamond crowd chain, Hercules gasoline and Caterpillar Diesel engines on Bay City shovels also employ high strength Nickel alloy steels for important stressed components.



More than 275 stressed parts in this dial type Cincinnati milling machine are Nickel alloy steels. Nearly 200 of these parts are made of a Nickel-chromium steel, heat treated to high strength yet readily machinable. Parts subject to wear are case-hardened.

Here are five Gardner-Denver rock drills mounted for tunnel driving. In each drill, 85 stressed parts are produced from Nickel alloy steels. The Gardner-Denver Co. writes, "Through increased use of Nickel alloy steels, remarkable improvements in performance and reduction in maintenance costs have been accomplished—without comparable increase in weight or bulk."

• • •

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# Iron *from* Heaven

By ROBERT F. MEHL and GERHARD DERGE
Department of Metallurgical Engineering
Carnegie Institute of Technology
Pittsburgh

INTEREST OF A METALLURGIST IN meteorites might be thought to be purely academic — it conjures the picture of a bespectacled geologist fussing with fossils while the world crashes outside his study window! Nothing could be further from the truth: The structure of meteorites has engaged the attention of some of the best metallurgical minds in the history of the subject, and these studies have been responsible for the development of an amazingly large part of the science of physical metallurgy, and future studies may well contribute further and important knowledge of alloys.

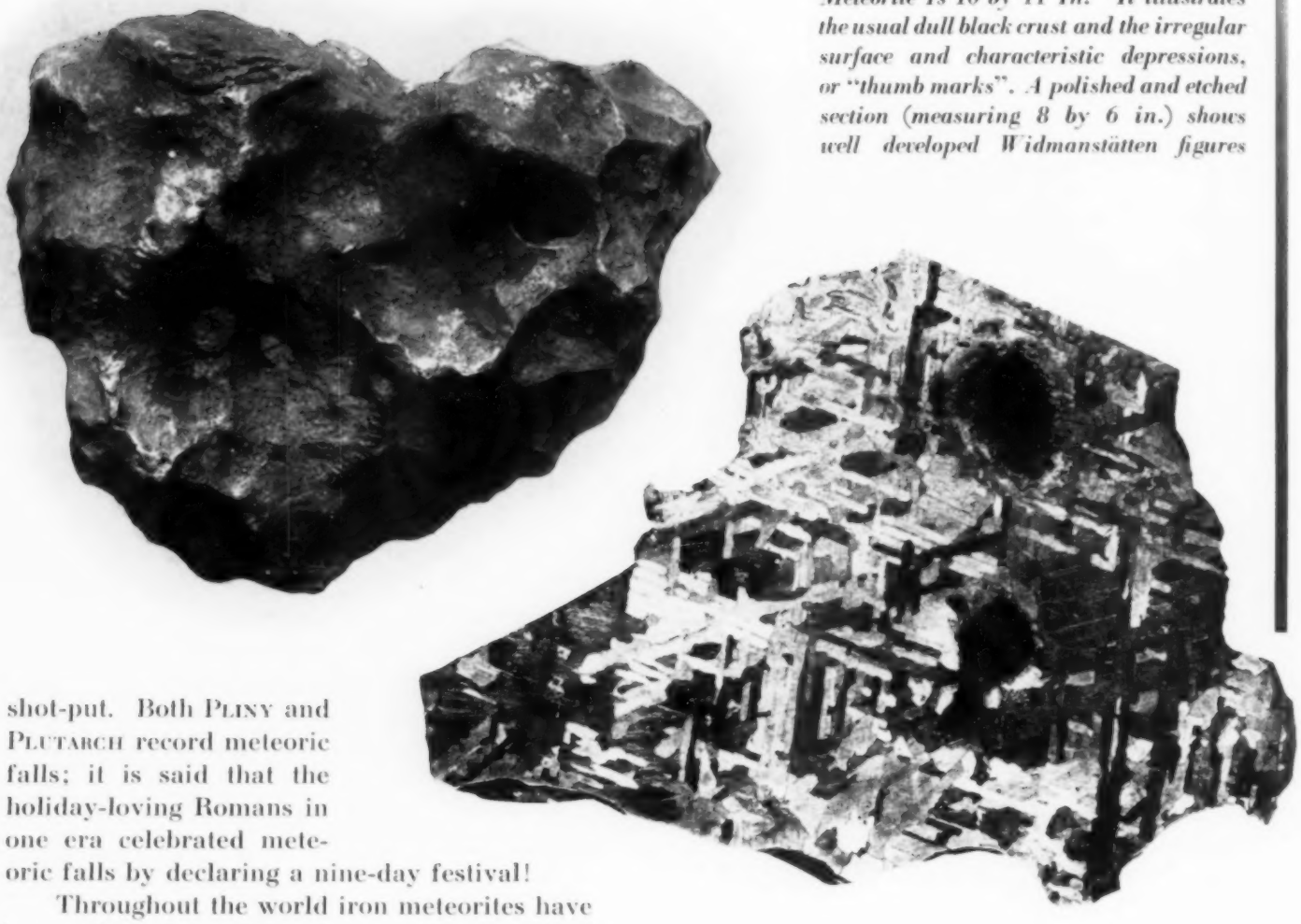
When in 1808, ALOIS DE WIDMANSTÄTTEN, Director of the Imperial Porcelain Works in Vienna, cut, polished, and etched a sample of a meteorite known as the Agram Iron and revealed the curiously and beautifully geometrical structure which has since borne his name, the smelting of metals and the making of alloys was an art, and there was little or no knowledge of their structure. Could he have foreseen the practical and scientific results which would in time ensue from his experiment, inspired by curiosity alone, he surely would have been much more pleased than he was. As a matter of fact, he was so little impressed that he didn't even publish an account of his work.

But the work attracted others, particularly the petrographers and mineralogists. A few years later the interest in meteorites was high, and the great FARADAY, the actual precursor of the alloy steel era, was in 1819 "led to try alloys of nickel and iron or steel, by the popular idea that meteoric iron was not subject to rust" as he wrote. This proved an unprofitable research, but it appears to be the first artificial production of iron-nickel alloys.

It is now known that meteorites are of three kinds: Iron (really an iron-nickel alloy), iron mixed with stone, and stone. Through the bronze age, man's only iron, which he valued very highly, was that which he hammered from iron meteorites. The lump of heavy material he had found to be malleable, so that by infinite patience he was able by hammering with a stone to raise an edge, then a fin, and finally a usable cutting edge. This sharpened metal with proper handles made any one of a wide variety of tools and weapons. When JOSEPH SABINE visited Greenland in 1818 with Sir JOHN ROSS, he found the Eskimos using such tools, and so did Admiral PEARY nearly a century later — his Eskimos had hacked their knives from a large meteorite known as the "Old Woman"!

But others, moved more by their fears of the supernatural than by their sense of the natural, saw meteorites as objects deserving worship. In the relatively recent year of 1772 a meteor was described as "a holy thing fallen from heaven", and enshrined in a place of worship. They may be found in many eastern temples. Others less hopeful imagined them to be the return of an evil spirit to earth, usually that of the petty tyrant who plagued the locality.

The ancients well knew the celestial origin of these objects, no matter what use they made of them. Chinese writings record, and thus recognize, a meteoric fall in 644 B.C. But recognition undoubtedly came much earlier than this among other peoples, for primitive Babylonian writings denote iron by two characteristics signifying "heaven" and "fire". The Egyptian word in a pyramid text in the sixth dynasty was "bia-en-pet", meaning "marvel from heaven", and a Hittite text of the 16th century B.C. speaks of "black iron of heaven from the sky". It is said that the Greeks, in an athletic celebration in honor of the funeral of PATROCLUS, rewarded the victor with a meteorite which evidently had been used in the



*Original Size of This Canyon Diablo Meteorite Is 10 by 11 In. It illustrates the usual dull black crust and the irregular surface and characteristic depressions, or "thumb marks". A polished and etched section (measuring 8 by 6 in.) shows well developed Widmanstätten figures*

shot-put. Both PLINY and PLUTARCH record meteoric falls; it is said that the holiday-loving Romans in one era celebrated meteoric falls by declaring a nine-day festival!

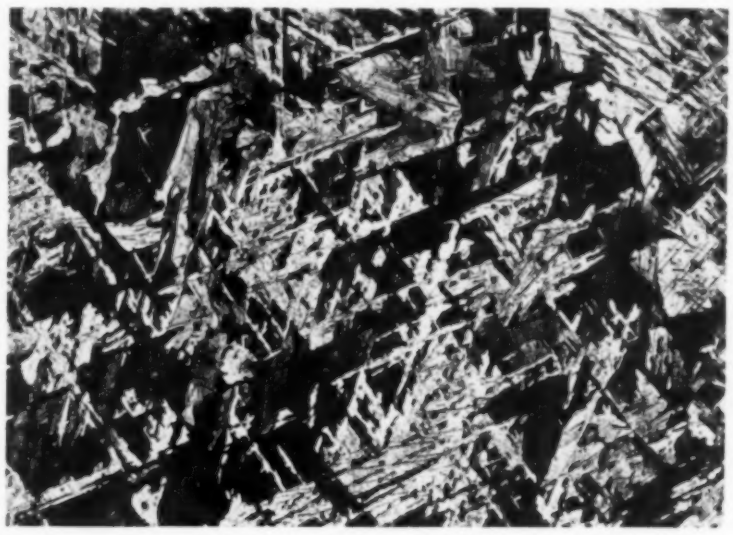
Throughout the world iron meteorites have been adapted to tools of some 44 recognized forms. ATTILA carried a sword, known as the "heavenly sword", made from a meteorite, as did TIMUR, much later, and certain of the Caliphs. Through the Middle Ages, the subject of meteorites became obscure until, in 1649, a certain learned person named TOLLIUS thought it necessary to reaffirm the celestial origin of these bodies, declaring meteorites to be "generated in the sky by a fulgurous exhalation conglobed in a cloud by the circumposed humour", a statement that was frightening but hardly enlightening. The Spanish invaders in Central and South America were mystified by the meteoric iron tools of the Aztecs and the Incas, and AMERIGO VESPUCCI found Indians in the La Plata region in South America using arrowheads made of meteoric iron. Even today such implements may be found among the few remaining primitive men.

It is related that when an aide once told THOMAS JEFFERSON that two Yale professors, KINGSLEY and the famous chemist SILLIMAN, had described a fall of stones from the sky at Weston in Connecticut, the President remarked, "It is easier to believe that two Yankee professors will lie than to believe that stones will fall from heaven!" It is one of those frequent perversities of history (or literature) that the celestial origin of meteorites was recognized very early and then forgotten, probably because such a conception had so many connotations of the supernatural as to prejudice it in the skeptical and even in the educated lay mind, as for example, in JEFFERSON's.

The French Academy of Science, in its wisdom, once thought it necessary to issue the ukase that "there is no such thing as celestial metal", feeling, evidently, that such a miracle should have no place in science, for in those days science was jealously guarded from the unusual. It was only after the beginning of the nineteenth century that CHLADNI, in Germany, and BIOT, in France, firmly established in the modern scientific mind that small celestial bodies do fall from the heavens and may be recovered. One theory of the origin of the earth has stated it to be an accumulation of meteorites, and that the growth from such

causes still proceeds and causes certain astronomical aberrations.

Modern knowledge of meteorites is comparatively complete. There is, of course, no doubt about their celestial origin. The meteorite approaches the earth from somewhere in interstellar space with a velocity of from 30 to 40 miles per sec. and loses much of this velocity on passing through the stratosphere and atmosphere. The velocity of a massive meteorite is naturally affected less than that of a small one, and when sufficiently large it may strike the earth with enormous velocity, liberating some 450,000 cal. per gm. of its mass, in comparison with the 1000 cal. liberated by the explosion of one gram of dynamite. Large meteorites bury themselves deeply in the earth's crust, if indeed they are not vaporized by the energy generated on impact. The transit through the atmosphere is short, and although the luminosity comes chiefly from the high temperature and ionization generated by friction with the air, the heat is only superficial and confined to a very thin crust and so rapidly dissipated that the meteorite, even when found immediately, is often comfortable to the touch and sometimes cold. "Shooting stars", which are minute meteorites, disintegrate quickly from the heat generated by passage through the air and disappear long before they reach the earth.



*This Photograph, Showing One Large Grain and a Smaller One on the Right Edge With Grain Boundary Between, Has a Magnification of 20 Diameters and Illustrates the Widmanstätten Figure in an Ordinary Steel Containing 0.17% Carbon. (Hanemann)*

The three types of meteorites are known scientifically as siderites (iron), siderolites (iron-stone), and aerolites (stone). The rocky material in the iron-stone and the stone meteorites is all of volcanic nature — no sedimentary rock occurs, and no vegetable or animal life has been found, though hydrocarbon gases have been identified; evidently the recent report of the discovery of micro-organisms in meteorites was premature. Meteorites have been classified according to variations in their chemical constitution in such a way as to lead to the conclusion that they originated in a single celestial body that had suffered a catastrophe, leaving these lone wanderers in celestial space. Meteorites have not been found in geological strata older than the Pliocene, and it is thus concluded that this catastrophe might conceivably have occurred within the geologic history of the earth.

Paneth in Germany (now in England) measured the helium content of meteorites and, employing the time scale of the radioactive decay series which produces the helium, calculated that meteorites originated at about the same time as our solar system, about $3 \cdot 10^9$ years ago. This calculation is very likely nearer to the truth than that based on geological evidence, which at best can only testify that meteorites were in existence during the Pliocene epoch.

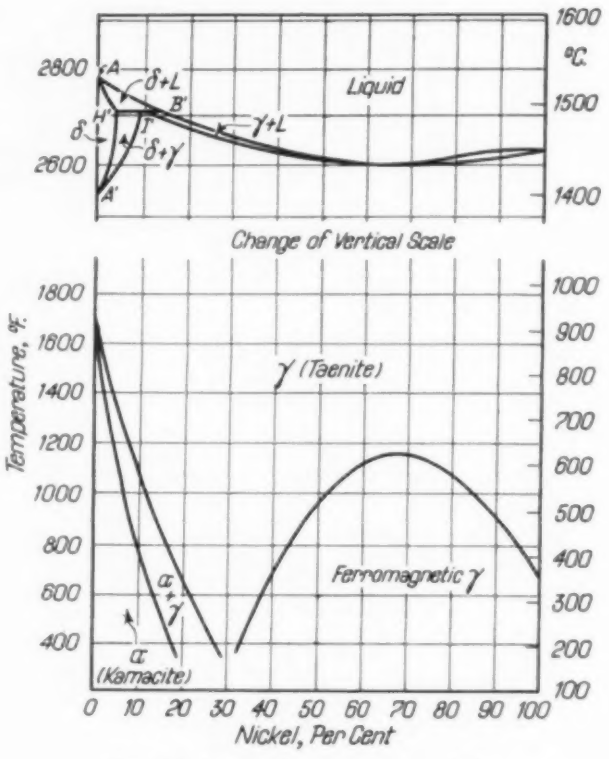
There is an average of four noteworthy falls of meteorites each year. These vary from a multitude of small stone meteorites to a single iron meteorite weighing tons. The famous Canyon Diablo in Arizona, a circular crater nearly a mile in diameter, is thought to have been caused by the impact of a meteorite now lying deeply buried. The iron meteorites forming the first illustrations of this article are from there. The supposed meteoric fall in Siberia in 1908 may, when better evidence is available (for Russian metallurgists do not seem to answer correspondence now!), prove to be the largest in history, for the country in an area of 50 miles was devastated. Perhaps H. G. Wells' story of the havoc wrought by a heavenly body approaching the earth too closely may yet be realized in an even more extreme form by the impact of a huge meteorite on some important center of population. Only the favors of chance guard against this.

Iron meteorites are largely alloys of iron and nickel; they contain on the average of 8% nickel, though the percentage is occasionally

much more or much less. It is interesting to note that the core of the earth, all the earth except the outer crust of several hundred miles thickness, is probably composed of such an alloy. At the pressures and temperatures which obtain there the alloy must be all austenite, if not in part molten. If solid, it would be hot enough to be austenite of unknown grain size, but if meteorites are any indication, perhaps a single crystal!

The interest of the mineralogists in DE WIDMANSTÄTTEN's first work lay chiefly in the geometrical characteristics of the pattern he discovered; mineralogists and crystallographers shortly studied this internal crystal structure much as they had long studied the external structure of ordinary crystals and minerals. In 1863 ROSE succeeded in cleaving a meteorite along the planes of the lamellae and produced a nearly perfect octahedron, a regular eight-sided solid. But why the meteorite possessed such an octahedral structure, and how the structure had formed, remained a mystery until the important *science* of physical metallurgy was developed in the 20th century. The earlier work on meteorites served, however, as one of the first convincing bits of evidence of the crystalline character of metals.

This mineralogical curiosity, the WIDMANSTÄTTEN figure, seemingly of only impractical importance, came as a stimulus to the birth of the science of physical metallurgy through the effort, not of a metallurgist — for in those days there were no physical metallurgists in the modern meaning of the word — but an English petrographer, SORBY, whom we have long recognized as the father of microscopic metallography. It is said that SORBY, recognizing that meteorites are really alloys, wondered whether ordinary alloys like steel might also be found to possess this structure when polished and etched. He knew that polishing and etching steel would not develop such a structure visible to the unaided eye, but thought that possibly the petrographer's careful technique of polishing and etching might develop a structure that would be revealed at high magnification. And he was right, for his sample of steel under the microscope was found to possess a structure quite similar to the figures in meteorites. Then OSMOND, in France, and ARNOLD and MCWILLIAM, in England, identified the structure in cast steel and in steel ingots; BELAIEW, in Russia, produced it deliberately by varying the cooling rate of ingots, and made a beginning at its crystallographic analysis; BENEDICKS, in Sweden, found it on a microscopic scale in artificial iron-nickel alloys (as had SORBY); and SAUVEUR, in America, called attention to its importance and its widespread occurrence, produced a WIDMANSTÄTTEN figure in pure iron, and suggested that martensite is but another, though somewhat special, example of this heaven-born structure.




*Equilibrium Diagram Selected by Marsh for the Iron-Nickel System*

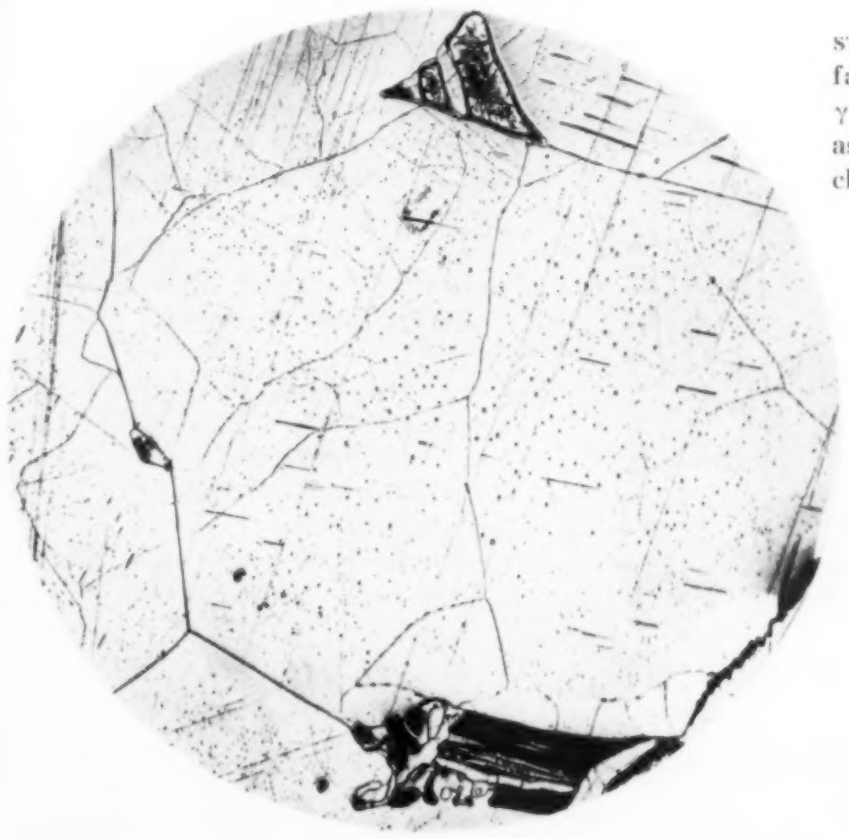
This verification and amplification of SORBY's findings had a far-reaching effect, for it taught those engineers interested in metals and alloys that they might learn much from a microscopic study of the internal structure of metals and alloys, and in this way many began such studies and became known as metallographers. The microscope thus became a most important piece of apparatus in the metallurgical laboratory. With SORBY's work the science of metallography began, and was shortly to be indispensable in studying and controlling the heat treatment of alloys and in the development of new ones, for it was found, as the veriest neophyte among metallurgists now knows, that the internal or microstructure of alloys bears a very close relationship to the properties, and that treatments that change the microstructure also change the properties.

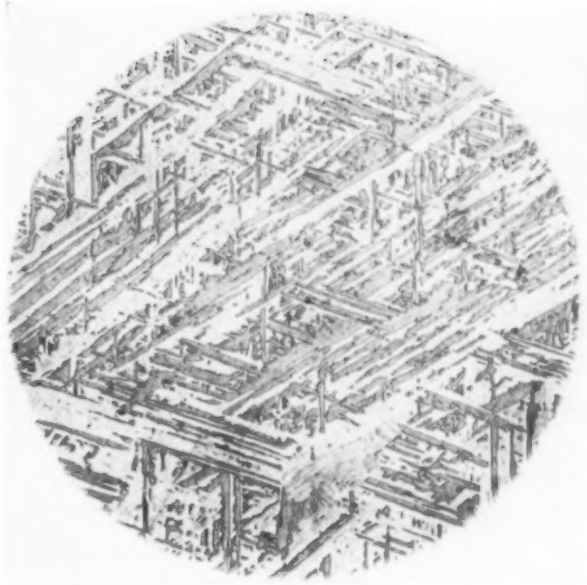
The WIDMANSTÄTTEN figure in meteorites shown on page 800 consists of striations of

kamacite, the α-iron solid solution, in the form of plates which on the plane of polish appear as elongated areas. These plates are formed by the slow transformation of the γ phase in the iron-nickel system stable at higher temperatures, lodging preferentially parallel to the {111} or octahedral planes of the γ crystal. Since there are four such planes, there is a maximum of four sets of plates, of which the traces of three may be easily seen in the Canyon Diablo meteorite, though the fourth is present also. Between these plates of kamacite lie layers of taenite which are the undecomposed residue of the parent γ phase.

Admixed with this is an eutectic-like structure known as plessite, composed of the α and γ phases, whose genesis is not thoroughly understood. The phosphides schreibersite and rhabdite occur, frequently arranged in a WIDMANSTÄTTEN pattern, and also slag and graphite inclusions. Diamonds have been found, but the reason that our large meteorite from Canyon Diablo was so difficult to cut through proved, to our distress, not to be caused by a diamond, and the effort to cut through the mass of metal turned into a simple study of the machinability of meteorites!

The crystallographic disposition of the kamacite plates was determined by ROSE and others, but these mineralogists apparently thought that kamacite, taenite, and plessite deposited in some sequence of precipitation from the melt, and did not see that the structure originated in a solid-solid transformation of the γ to the α phase. SORBY, who studied both meteorites and artificial iron-nickel alloys, knew





*An Artificial Iron-Nickel Alloy With 27% Nickel, Very Slowly Cooled; Magnification 25 Diameters*

better than this, recognizing the presence of a transformation of one solid into another solid, which transformation should be responsive to heat treatment. The complete explanation was given by OSMOND and CARTAUD in 1904 who, having consulted ROOZEBOOM, published the first concentration-temperature diagram of the iron-nickel system and were among the first to use such diagrams — inspired, as you will note, by an interest in the WIDMANSTÄTTEN figure. Its formation was then correctly ascribed to the deposition of the α phase from the γ phase, the latter being stable only at higher temperatures.

### *Uniquely Large Crystals*

Since it will be observed that the WIDMANSTÄTTEN figure is uniform across the whole surface of our meteorite, it follows that the original γ phase was a single crystal — a single crystal as large as a meteorite! The single crystal character of the γ phase suggests that the mass had frozen with extreme slowness, and in fact the coarseness of the WIDMANSTÄTTEN figure certainly suggests the same thing. Attempts to reproduce the structure in artificial alloys, while successful, as may be seen in the photomicrograph above of a 27%

*Photomicrograph of Kamacite in a Canyon Diablo Meteorite. The long diagonal lines are Neumann bands; the short, nearly horizontal lines are the phosphide rhabdite; the coarse network of fine lines is veining. Magnification 60 diameters*

nickel-iron alloy, have never succeeded in producing it on as gross a scale as it occurs in meteorites, owing to the impossibility of reproducing geologically slow cooling rates.

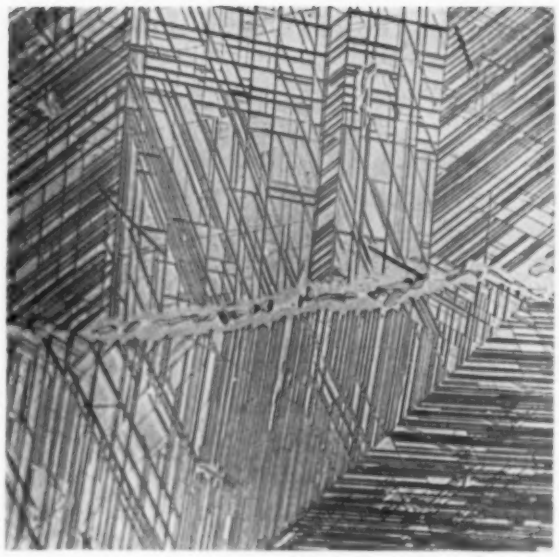
It is interesting to note that early workers observed NEUMANN bands in the kamacite layers, and it has been suggested that this may be taken as evidence that meteorites had suffered impact sometime during their history, as the Canyon Diablo and the redskins thereabout at the time might well testify.

Shortly after OSMOND's work, as the studies of the microstructures of alloys grew, many WIDMANSTÄTTEN-like figures were found in other alloy systems and even in non-metallic systems, and it was suspected that the formation of such figures might accompany any transformation in the solid state. It was observed, especially by SAUVEUR, that martensite forms a structure in which the needles appear to be disposed according to crystallographic symmetry, and this too was claimed as a WIDMANSTÄTTEN figure.

It may be seen that OSMOND and CARTAUD neglected to consider any possible effect that the crystal structure of the precipitate might exert in the formation of the figure. It was not until 1926 that YOUNG determined a few of the relative orientations of the $\alpha$ and $\gamma$ phases in the structure as found in various alloys, and showed that the planes of atoms in the two phases lying opposite each other at the $\alpha$-$\gamma$ interface are very closely similar in atom pattern and interatomic distance.

X-ray studies have shown later that there is considerable difference in the state of crystal perfection in the kamacite layers among meteorites, with the fine-grained meteorites (those having a fine WIDMANSTÄTTEN pattern) exhibiting a low state of perfection. It will interest the metallurgist to note that typical $\alpha$-veining occurs in the kamacite, though there seems to be no connection between crystal perfection and the prevalence of veining.

In 1930, and the succeeding years, the basic reason for the orientation relationship shown in part by YOUNG was demonstrated, namely, that one crystal phase forms from another by a series of lattice movements which ordinarily can be described as a series of shearing operations. These movements are relatively slight, but they suffice to create the new lattice from the old, creating it in an outward form which reflects the simple geometry of the lattice movements. Such studies thus give us a picture of the atomic-crystallographic mechanism by which one phase may be born of another, and accordingly have provided us with a great deal of information on the age hardening process and on processes such as lead to martensite-like structures. Much work of this sort on the analysis of crystal forms has been done at Metals Research Laboratory of Carnegie Institute of Technology.



*Widmanstätten Figures in Structures Similar to This May Be Found in a Wide Variety of Alloys. This one is in an alloy of cobalt and 35% tungsten made by W. P. Sykes, magnified 500 diameters*

*This Shows White Martensite in a Matrix of Austenite. It was formed at —190°C. in a 6.5% manganese, 0.92% carbon steel. Magnification 2000 diameters. (J. R. Vilella)*

It is easy to see, then, that meteorites throughout the history of man have been of importance to the workers of metals, and even to the trained modern metallurgist. Will meteorites continue to be of use in understanding the fundamental problems of metallurgy, and will metallurgists continue to turn to them for help? If history may be taken as proof, the wary metallurgist will not neglect these celestial visitors, this iron made in heaven.

# Correspondence from Home & Abroad

## How to Remove a Bottleneck in New Furnace Equipment

Letter from STEWART N. CLARKSON
Executive Vice-President
Industrial Furnace Manufacturers Asso., Inc.

NEW YORK — In view of the fact that orders for heat treating furnaces are being placed at a rapidly increasing rate, despite a volume of deliveries which reached an all-time high several months ago, the Industrial Furnace Manufacturers Asso. made a survey of its membership and found the following conditions to exist, as of November 1 among makers of furnaces shipped complete from the factory: Nearly all of them could increase their output 10% without extending deliveries, and could raise their output another 25% if purchasers would order far enough in advance to give them two months' production time.

Conditions are not so easy among manufacturers of large furnaces built on the users' premises. About half the manufacturers of this equipment cannot maintain present deliveries with any further increase in volume unless there is a greater acceptance of established designs by users. The balance of the manufacturers of this equipment can still increase their volume by about 25% without extending their delivery schedule, and could do still more if users would not insist on minor innovations in design, intended to improve details, which cause delay in delivery of a month or more.

A further increase in production of from 25 to 50% could be effected if users would (as they very often could) give the furnace manufacturers 60 days more time in which to build the equipment.

Some furnace manufacturers have had the discouraging experience of finding, upon delivering a furnace on schedule, that either the building which was to house it was not nearly completed, or that the forging hammer to be used with the furnace was not to be delivered for another month or two. These are given as typical examples where the insistence upon unnecessarily short deliveries has been detrimental to other users who really needed the equipment.

It is also claimed that in other cases the machine tools for a new plant have been ordered months before the furnaces. Had the orders been placed simultaneously the delivery problem would have been easy, but such delays in placing orders put an unnecessary burden on the furnace industry which, in turn, reacts to the disadvantage of other participants in the national defense program.

The Industrial Furnace Manufacturers Asso. has worked closely with the Ordnance Department, U.S.A., on problems of mutual interest, and now turns to its customers for cooperation, in order to maintain the supply of furnaces necessary to meet the demands of the defense program.

The following specific ways have been suggested in which users' cooperation would be most helpful:

1. By issuing orders for furnaces among the first orders placed for equipment.
2. By not insisting on shorter deliveries than are absolutely necessary.
3. By utilizing in every way possible the successful designs which have been established by the different furnace manufacturers to meet practically all requirements of ferrous and non-ferrous products.
4. By reviewing the delivery promises of equipment already ordered and, where there has been a delay on some other essential piece of equipment or building, notifying manufacturers of furnace and other equipment that they can have that much more time in which to make deliveries. This would afford immediate relief.

STEWART N. CLARKSON

## War Note

"FOREIGN Correspondence" is becoming a euphemism. As mentioned on the next page, no word has been received from Professor PORTEVIN since the armistice; the other occupied and controlled countries also exist, seemingly, in a postal vacuum. German and Italian letters and papers arrive five or six weeks after date, presumably having traveled by way of Japan. Letters to and from England require about three weeks. American friends of J. H. G. MONYPENNY, metallurgist for Brown, Bayley's Steel Works in Sheffield and authority on the stainless steels, will be interested in the following note dated Oct. 31:

"We are still carrying on very much as usual in Sheffield. I do not know whether it is because 'Jerry' cannot find us, or if he thinks he will let us alone for the time being. The fact remains that Sheffield has been practically untouched by bombs. We had a few after I wrote to you on August 21, but their results were negligible. They certainly damaged a few houses and broke a number of plate glass windows, but not a single one of the larger steel works has been damaged in the least.

"London seems to have borne the brunt of the Nazi spite and there is little doubt that their bombing is entirely blind. Their planes, when they manage to get to London (and on many occasions they are turned back), appear to fly over the city as fast as they can and unload their bombs anywhere. Naturally a considerable amount of damage to property has occurred; damage of military importance appears, however, to be very slight indeed and I should say that over the whole country our war productive capacity has been hardly affected."

## Toughness (Impact Strength) as Affected by Alternating Stresses (Fatigue)

Letter from H. W. GILLETT
Chief Technical Advisor
Battelle Memorial Institute

COLUMBUS, *Ohio*—The data from DE LACOMBE, cited by Professor PORTEVIN on page 563 of the May issue do not justify the conclusion drawn. Neither is it correct to say that the experimental method of attempting to appraise fatigue damage through an impact test has not been previously tried. HONDA (*Science Reports*, Tohoku University, v. 16, 1927, p. 265) and OSHIBA (ibid., v. 23, 1934-5, p. 589; v. 26, 1937, p. 323), GÜRTLER (*Zeitschrift für Metallkunde*, v. 32, Feb. 1940, p. 21) and the Bureau of Standards (25th Annual Report of the National Advisory Committee for Aeronautics, 1939, p. 38) have all utilized such methods.

PORTEVIN does not record the endurance limit of the steel tested, so that it is not apparent how the stresses recorded compare with that value. Obviously the impact specimen tells what has or has not occurred at the base of the notch, not what has occurred at the surface of the original specimen which has been machined off. The stress at the location within the fatigue specimen, which is to be the location of the base of the notch, is not, in a rotating cantilever specimen, the same as it is at the surface of the cross section at notch; it is much less, since the stress falls off to zero at the axis. It seems inconceivable that Professor PORTEVIN should have forgotten this and reported the surface stress rather than the actual stress at the point where the base of the notch is to come.

But whether this error was made or not, the stress gradient is such, in a rotating specimen, that a point only one-third the distance out on the radius is not stressed anywhere near the endurance limit, and cannot become damaged until a crack penetrates to it from the surface.

Therefore specimens taken as DE LACOMBE's were should show no damage when impact tested. Other workers have realized this. GÜRTLER points out that cutting out a notched specimen from a regular fatigue specimen can give no information on damage. He used previously notched fatigue specimens, ran them various fractions of their lives according to the S-N curve for notched specimens, then broke the whole specimen in single blow impact. By this means he established a notched specimen damage line whose location was reasonably close to that of the damage line established by the technique of FRENCH, reported to the A.S.M. in the 1933 Campbell Memorial Lecture.

If the specimen is axially loaded, by push-pull, over its whole section, then the criticism as to the stress gradient no longer holds and a notched impact specimen could, theoretically, be cut from any location in the uniformly loaded gage length. Actually this would not necessarily show the true degree of damage, since loading is never perfectly axial and, even in push-pull tests, some place on the surface actually has the maximum stress. To show the advent of the damage at this most vulnerable point, the Bureau of Standards has made tensile-impact tests on Haigh machine specimens

after various fractions of their life. This is an intelligent way to attack the problem.

The data cited from DE LACOMBE are just what would be expected; the material at the notch had never been overstressed, and the impact behavior should be unaffected. Proper application of the method does not give negative results. This seems to be another case of unilateral and retroactive blockade such as was cited on page 532 of the May issue!

H. W. GILLETT

**Editor's Note:** — A copy of this letter was sent to Professor PORTEVIN on May 18, asking him for comment which could be appended as a rebuttal, thus closing the matter. However, the letter was either not delivered or something has prevented a reply. No letters from France, free or occupied, have been received by METAL PROGRESS since the armistice was signed with Germany. The letter from Dr. PORTEVIN, published on page 810, was posted prior to that date.

## Zircon, a Desirable Facing and Wash for Foundry Use

Letter from GEORGE F. COMSTOCK
Metallurgist, Titanium Alloy Mfg. Co.

NIAGARA FALLS, *N. Y.* — Evidently a transposition of words crept into Mr. BREMER's article on "Steel and Iron Castings", page 373 of the October issue of METAL PROGRESS, where he mentions the use of zirconia and aluminum silicates as improved foundry refractories, whereas the materials actually used are alumina and zirconium silicate which we call zircon. Zircon has indeed shown much merit and is growing in use as a facing sand, mold wash and core material in the production of castings that must have good surfaces and be easy to clean. This material, which is practically pure zirconium silicate, is marketed under the trade name "Zirconite". It is much more refractory than ordinary foundry sand or even silica, and therefore does not fuse or soften when extremely hot steel is poured against it. For this reason zirconite does not adhere readily to the surface of the casting and the labor required for cleaning is greatly reduced.

Since zirconite costs somewhat more than common foundry sand, it is generally used merely as a facing or wash. The granular form is used for facings, and it can be bonded the same as other sands and causes no difficulty when mixed with them. It is quite fine, however, being mostly between 100 and 140 mesh in size, so that careful venting is required. It also has a slightly greater chilling effect than ordinary sand. When used as a wash, a finely milled powder prepared with a small amount of a suitable inorganic binder is applied in suspension in water. In dry sand work such a wash is often just as effective as a zirconite sand facing, and is somewhat less expensive and more convenient to apply.

Zirconite is chiefly useful, of course, for small castings of highly alloyed steels, where the pouring temperature must be very high. Internal threads have even been cast in small cored holes in stainless steel castings by using zirconite for the cores. In large castings of comparatively thin section, where the pouring temperature must be higher than usual, zirconite has also found an important field of usefulness, and even in cast iron, both gray and malleable, the saving in cleaning costs has made its use distinctly economical in many foundries, even though the pouring temperatures for these metals may not be exceptionally high.

GEORGE F. COMSTOCK

## A Ghost

*Discovered by Jack I. Medoff, in the Metallurgical Laboratory of Worthington Pump & Machinery Corp., Harrison, N. J. He thinks it might be Master Will B. Godley, down-hearted, henpecked husband of Mistress Prudence Godley, whose wraith appeared in Metal Progress for last April (page 439)*

## Plastic Deformation in Metals

Letter Commenting on Dr. Hoyt's Campbell Memorial Lecture
From Edward Adams Richardson

BETHLEHEM, *Pa.* — I was impressed, on reading the account of the Campbell Memorial Lecture, with Dr. Hoyt's difficulty in accounting for the strengthening by slip of other planes than those where slip actually occurred. The phenomenon becomes simple when it is remembered that atomic force fields in metallic crystals are three-dimensional and that the third direction does take its part in what happens in the other two directions. It is furthermore necessary to replace a "block" type of theory with an atom force theory, in which atoms may exchange partners without a total breaking of the field of force between them at any time during the movement. It is essential to remember that, though atoms of pure substances may form the lines and planes necessary for slip to occur, a very small amount of distributed impurity seriously interferes with this tendency.

Since no two planes of atoms in a slightly impure substance (such as a first grade commercial metal) fully fit each other, some atoms will necessarily be displaced from the normal position in the crystal lattice and under strain. The greater the number of points of strain, or displacement, the easier it should be for a shearing stress on that plane to cause slippage. [Editor's note: This seems to contradict the slip interference theory of hardening, which states that irregularities in the atomic lattice *increase* the resistance to slip.] If slippage occurs, atoms in neighboring planes pass continuously from the field of action of the original partner to that of the adjacent partner. It is quite likely that after

*(Continued on page 858)*

## Exposure Chart for Radium Radiography

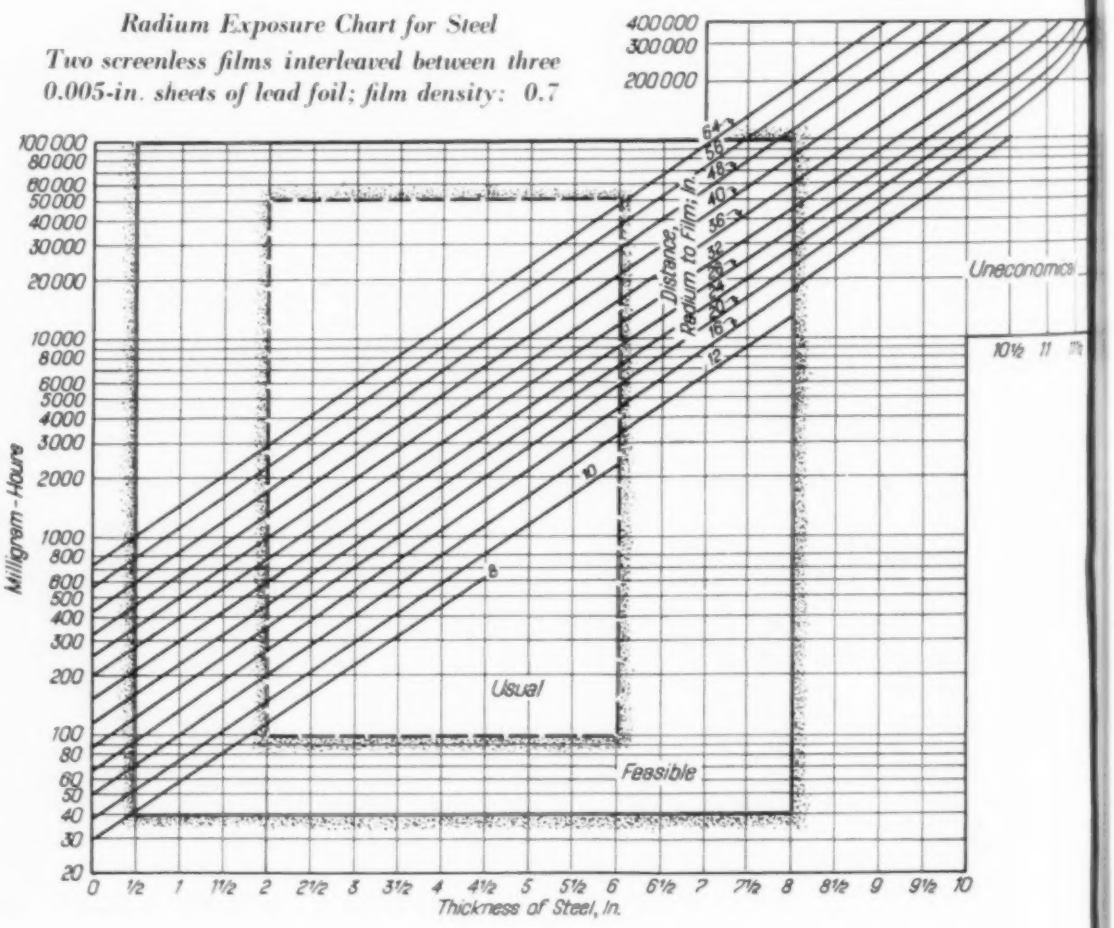
Letter from Herbert R. Isenburger
St. John X-Ray Service, Inc.

LONG ISLAND CITY, *N. Y.* — Herewith is a revised chart showing the approximately correct exposure for the radiography of steel with radium (not radium emanation). It is based on a similar chart prepared some years ago and published in the author's book "Industrial Radiography"; the changes are the result of practical experience with the "screenless film" rather than of experimental data of laboratory derivation.

In ordinary X-ray work, we are using intensifying screens on both sides of our film. Film manufacturers are now supplying a new type of film which does not require the use of these intensifying screens, and this film is known as screenless film, or non-screen film. It is fairly well known to users since it has been on the market for well over one year.

As indicated in the caption, we recommend two such films interleaved with three 0.005-in. sheets of lead foil; by such means results can be achieved in about half the time formerly

*Radium Exposure Chart for Steel*
*Two screenless films interleaved between three 0.005-in. sheets of lead foil; film density: 0.7*



required. We have used the new screenless or non-screen film for a period of one year. By comparing exposure data for the new technique with that of the old one, we established the new charts. No other factor but the type of film has been changed.

I had recently occasion to compare some of our results with two or three other users, and we checked very well indeed.

HERBERT R. ISENBURGER

## Hardenability of Carburized Steels

Letter from W. H. BRUCKNER
Research Assistant Professor of
Metallurgical Engineering
University of Illinois

URBANA, *Ill.* — WALTER E. JOMINY in his article on "Commercial Aspects of Hardenability Tests" in November METAL PROGRESS comments on a statement published in the University of Illinois *Bulletin* on "Hardenability of Carburizing Steels", of which I am the author. The statement is correctly quoted, but it should be noted that reference is made to the rather low surface cooling rate of approximately 5° F. per sec. through 1300° F. at 2½ in. on the JOMINY bar, which is equivalent to the center cooling rate of a ¾-in. round, cooling in air. It is to be expected that an inappreciable gradient should exist between the surface and a depth of 0.015 to 0.020 in. below, where maximum hardness is usually found in the carburized S.A.E. 4615 steels, when cooling on the surface at this rate. For such low cooling rates the correspondence of the JOMINY bar hardness, at various depths down to 0.020 in., with a large gear or bearing should be close.

In the *Bulletin* the test was actually applied to a bar 1 in. round, the same as the JOMINY bar diameter, which was carburized in the same manner and quenched in oil from 1700° F. The hardness at various depths was compared with that of the JOMINY bar at ⅛ in. from the water-cooled end and at various depths. Excellent checks were obtained for the 0.026-in. depth in both bars. Therefore, if hardenability in a carburized bar were a function of cooling rate alone, we could say that, at the 0.026-in. depth, both bars cooled at the same rate.

From tests conducted on a number of the S.A.E. 4600 series with varied carbon it was found that the austenite with a carbon range of 0.94 to 0.78% has the highest stability. However, the stability of the narrow region in the carburized bar within this carbon range appears to depend upon the progress of the transformation in the higher and lower carbon regions between which it is interposed.

The difference in the cooling behavior of the JOMINY bar and a bar or other shape cooling fully immersed in a liquid medium has been explained by him. In the former the cooling rate is approximately the same across a plane in the bar parallel with the water-cooled surface, while in the latter case a temperature gradient is established which is dependent upon the severity of the quench and the surface-to-mass relationship. This difference in method and reasoning was discussed in the *Bulletin* and possible effects on hardenability were suggested for the differences in stresses accompanying the transformation in both cases, and the probable different environment of similar areas in the carburized case undergoing transformation by both methods of cooling. For surface cooling rates equivalent to that of the JOMINY bar 2½ in. from the water-cooled end, these differences should be negligible because of the slight temperature gradient.

In his article last month Mr. JOMINY has applied the test to uncarburized material, and the study of hardenability is therefore not complicated by the carbon gradient. The industry has widely accepted the application of the test to such steels with gratifying results.

W. H. BRUCKNER

**Mr. Jominy's Comment:** — Prof. BRUCKNER's remarks are appreciated. There is one point which I hope will not be confused and that is the procedure in comparing cooling rate on the end-cooled bar with that at a certain location on any machine part being heat treated. If we consider the quenched gear, referred to in Prof. BRUCKNER's quoted statement, and assume that the cooling rate is the same for gear and end-cooled bar at 0.026 in. beneath the surface of the gear and at 0.026 in. beneath the surface of the end-cooled bar at 2½ in. from the water-cooled end, then the cooling rate at the surface of the gear and the surface of the bar at 2½ in. from the water-cooled end will definitely *not* be the same. The cooling rate at the surface of the gear will be higher than the cooling rate at 2½ in. from the water-cooled end on the surface of the bar, and perhaps correspond at say 1 in. from the water-cooled end. This will be true whether the gear and bar are both carburized or not carburized. The reasoning can easily be confused in making these comparisons though it is really quite simple.

## Malleability, a Metallic Property

Letter from ALBERT M. PORTEVIN
Consulting Metallurgical Engineer

SOMEWHERE IN FRANCE — The property most characteristic of the metallic state and most easily determined with precision is electrical conductivity (or its reverse, electrical resistivity) provided flawless test pieces of appropriate shape are used; otherwise the thermal coefficient of conductivity may be substituted. To this property may be added others equally characteristic, namely, metallic luster and opacity to visible light.

There is still another metallic property which is very important from a practical viewpoint and which should be considered, jointly with electrical properties, in characterizing the perfection of the metallic state. It is the property of malleability; it may be estimated either by rolling or hammering — or even better by drawing, when it is called ductility.

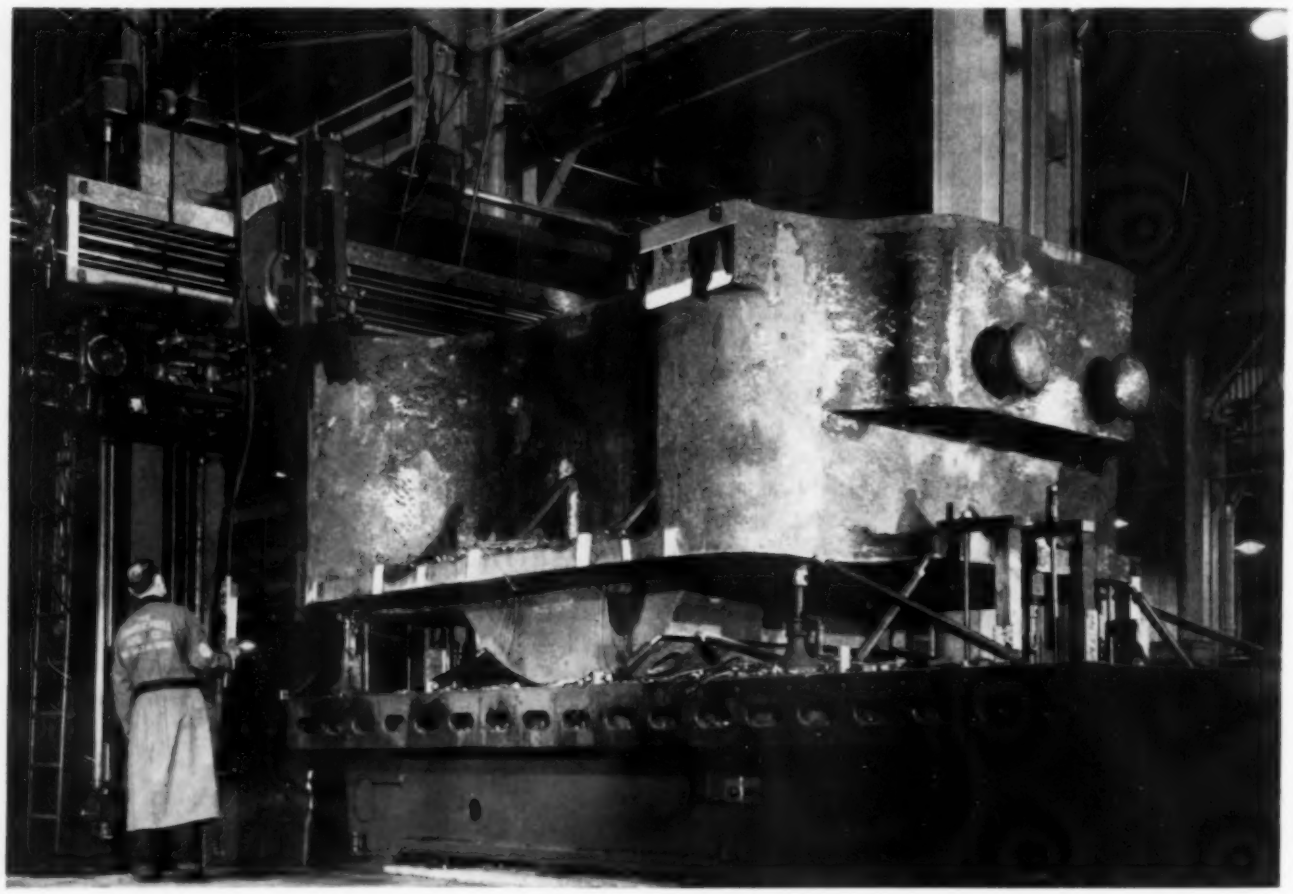
Thus, among metals, the most highly conductive and the most ductile are the "true metals" of face-centered cubic lattice (and belonging to Groups VII and VIII of the periodic table of the chemical elements).

Certain industrial metals are brittle, such as manganese refined electrothermically or chromium obtained by electrolysis, but this seems to be because they are not of sufficient purity; very pure manganese prepared by MARIE GAYLER is ductile. The same is true of chromium. There are no pure metals that are not malleable.

Therefore, when a metal is not malleable, or has low electrical conductivity, it is because of insufficient purity. (We gave a good example of the influence of the degree of purity on malleability in "Impurities in Metal Known and Unsuspected" in METAL PROGRESS for March 1932, page 69.) However, it is not so much the percentage of impurities that counts as the nature and condition of the impurities — namely, whether they are present in solid solu-

*One Reason Why Aircraft Cannot Be Delivered Overnight*

*A 142,000-lb. casting, the bed of a 5000-ton press destined for an aircraft factory, being machined in the newly expanded plant of Hydraulic Press Mfg. Co. Some of the machinery to equip this new machine-building plant was on order in 1937*



tion or exist as inclusions in a separate phase. In the latter case, the specific properties of these inclusions (conductivity and malleability) and the structural characteristics (form, fineness, and distribution) may play a part, as we have already shown (see "Estimation of Inclusions", METAL PROGRESS, July 1939).

Thus, a vanadium analyzing 100% prepared in 1900 by MUTHMAN was as brittle as glass, while vanadium obtained by VAN ARKEL by the dissociation of its iodide in vacuum is very ductile. Titanium and zirconium prepared by this method are also ductile, while they are not when obtained by another method.

These last two metals become brittle by absorption of small quantities of nitrogen, or when heated to a high temperature, when they absorb dissolved oxide. On the other hand, as much as 1% hafnium changes the mechanical and electrical properties of zirconium but little.

Oxygen impurity, always present in remelted metals, often has a deleterious effect on malleability, yet we should not generalize. BOLTON and DE BOER have shown that thorium containing up to 18% oxide remains ductile; in this case, the oxide is quite insoluble in the solid metal.

We are thus tempted, with VAN ARKEL, to define the purity of a metal not by its chemical analysis but by its properties, the metal being purer as its physical, chemical and mechanical properties more closely approach those of the ideally pure metal, as indicated above.

In general, the most effective purifying actions are those eliminating oxygen, nitrogen and carbon. We might thus distinguish between *chemical* purity, which would be the absence of elements in solid solution, and *physical* purity which, by analogy with optical purity of liquids and gases, would be the absence of insoluble particles or inclusions.

If we now consider alloys, or, rather, intermediate phases or intermetallic compounds, these may be either conductive and malleable, (that is to say, metallic in character, such as the cubic-centered $\beta$ phases of electronic concentration 3/2), or they may be non-conductive and brittle (such as the $\gamma$ phases with large multiatomic lattices of electronic concentration 21/13). Here, again, malleability — or its reverse, brittleness — are very definite metallic characteristics.

Finally, in considering the phases formed by metals with metalloids, the writer and R. CASTRO tried to classify the ones found in steels into non-metallic inclusions and metallic constituents, basing their estimates principally on malleability and optical characteristics. The metallic character increases in the order O → S → N → C for the same cation, so that it is possible to make a conventional division by classifying silicates, aluminates, oxides and sulphides as inclusions, and classifying nitrides, carbides (and borides) as metallic constituents.

ALBERT M. PORTEVIN

## Lithium Alloys Now Sold in Ton Lots

Letter from H. OSBORG
Vice-President, Lithaloys Corp.

NEW YORK — On page 529 of the October issue of METAL PROGRESS, reference is made to lithium by C. L. MANTELL in his review entitled "New Uses of the Minor Metals". The first sentences of the paragraph headed *Lithium* convey the thought that lithium metal and lithium alloys are produced and used, but only on a laboratory scale. Of course, many of the new and suggested uses have been and still are applied on a small scale.

However, the metallurgical public will be pleased to know that actually metallic lithium has acquired commercial importance. Lithium metal, and alloys containing 30% of lithium and more, have been produced on a commercial scale and their consumption has aggregated several thousand pounds within a comparatively short time.

In order to obtain a proper conception of the still young industry, one must consider the low specific gravity of lithium (only one-half that of water). Also, lithium is added in amounts of but 0.005 to 0.025% to treat molten metals and alloys. Taking 0.015% as an average, 0.3 lb. of lithium suffices for one ton of metal. In other words, each thousand pounds of lithium corresponds to more than 6,500,000 lb. of treated metals, like copper or copper alloys, produced and marketed.

Since the introduction of "lithium master alloys" (carrier or base metal like copper or aluminum, containing up to 10% lithium) late in 1938, several of them have been developed and produced on an increasing commercial scale. With just the surface scratched in the non-ferrous field, and large development under way in the ferrous field, individual consumers already require lithium master alloys in ton lots.

H. OSBORG

# Buy Him a Book for Christmas

## Cast Iron Viewed as an Alloy of Silico-Iron and Carbon

THE MICROSCOPE IN ELEMENTARY CAST IRON METALLURGY, by Roy M. Allen, 160 pages, 6x9 in., 73 illustrations. American Foundrymens Association, Chicago. Price $3.

Reviewed by GARNET P. PHILLIPS

In this book the value and uses of the microscope to the cast iron foundryman are enumerated in a clear, concise way. Fundamentals of physical metallurgy are given with emphasis on the four major constituents of cast iron (ferrite, pearlite, cementite and graphite), the conditions which cause their formation and the effect of each on the characteristics of the metal.

A series of photomicrographs showing graphite flake size and distribution in irons of various strengths introduces a discussion of effects on metal properties. Others show various types of pearlite (including sorbite and spheroidized pearlites) with similar data and discussion. The effects of silicon on graphitization and on the nature of the pearlite are discussed with excellent examples of ferritic irons shown; similarly for cementite. A thorough discussion of effects of sulphur, manganese and phosphorus on the properties of cast iron is given with illustrating micros.

A section is devoted to special cast irons including white and chilled irons and malleable iron. The types of castings produced in chilled iron, solidification phenomena, and the effect of microstructure on the properties of the chill are briefly discussed and excellent photographs shown. The microstructure of malleable iron is briefly described and illustrated along with an explanation of galvanizing embrittlement. A short discussion of alloy cast iron, special duty irons and heat treated cast irons is also included.

The author states that there is a growing tendency to question the value of the double equilibrium diagram for iron and carbon, as proposed by Benedicks to explain the presence of graphite in gray irons, and advances a proposed diagram for gray iron. His proposed gray iron diagram is based on the postulates that a correct equilibrium diagram is highly desirable for predicting the methods to be employed in any specific instance for producing it; that a true equilibrium condition must obviously exist for gray cast iron at any temperature, and the correct diagram is one which shows the true condition at all temperatures; that the ordinary diagram for iron and iron carbide satisfactorily explains mixtures free from graphitizing agents but is inaccurate when graphitization takes place and should, therefore, stand as the proper explanation of a stable carbide system while a modified diagram is essential to explain gray cast irons; that, since gray iron is never produced without the presence of a graphitizing element, a suitable equilibrium diagram should take the presence of such graphitizing agent into account; and finally that, since high quality gray cast iron is never in a condition of equilibrium, a correct diagram should indicate the procedure to be followed to obtain the proper deviation from equilibrium.

He advances the idea that, instead of conceiving of the diagram as being one of iron and carbon (or even of iron, carbon and silicon), the diagram should be of a mixture of carbon and a new metal with a proposed designation "silico-iron". This designation is to imply only a few per cent of silicon in solid solution in iron. Evidence is given to support the idea that the diagram should be of silico-iron and carbon instead of iron and iron carbide.

The suggested equilibrium diagram for silico-iron and carbon superimposed on another for iron and iron carbide differs from the latter in that the upper end of the line representing solubility of carbon in gamma iron is shifted progressively to the right with increasing silicon percentages, and its lower end from the 0.85% eutectoid carbon point to zero carbon; changes in curvature also occur. The line repre-

senting the limit of carbon solubility in molten iron changes in slope, representing a lowering of the eutectic point (4.3% carbon with 0.0 silicon) and a raising of the solidification temperature. In other words, the intersection of the line representing the limit of carbon solubility in molten iron with the line representing solidification is shifted to the left and up, and of course the line of solidification is moved up.

Such a diagram is claimed by the author to provide a real working basis for the cast iron metallurgist in the solution of his problems. A suggested gray iron equilibrium diagram is shown embodying the above ideas in which the compositions within the steel range are omitted. Graphs are given showing relation of carbon solubility, cooling rate and graphite precipitation rate.

The final section of the book is on the microscope and technique of its use. The discussion includes a description of the parts of the microscope with emphasis on the optical system and illumination. Numerous illustrations of equipment are shown. Sample preparation is thoroughly discussed, and is followed by a section on etching and etching reagents.

The photographs used to illustrate microstructures are really excellent, and the book is of value to cast iron metallurgists, metallographers and foundrymen.

## The Science and Art of Metals

PRACTICAL METALLURY, by George Sachs and Kent R. Van Horn. 567 pages, 6x9 in., 335 figures and 155 equilibrium diagrams. American Society for Metals, Cleveland. Price $5.

Comprehensive and up-to-date are two words for describing this new book. It is, indeed, so loaded with facts that it is not easy reading. But it evidently is not intended for "reading" so much as for study and reference. Solutions, or ideas leading to the solution, of nine out of ten problems which may puzzle metallurgists and metallographers can be found within these covers. Encyclopaedic is the word for it!

The authors have used the plan of discussing general principles and then citing important examples from commercial metals or specific alloys. One third of the text is devoted to the principles of physical metallurgy and two thirds to various operations in the manufacture of metals and alloys. Thus it justifies its title as being predominantly practical rather than theoretical. In view of the life work of both Dr. SACHS and Dr. VAN HORN, it is natural that a majority of the instances are from the light alloys; a comprehensive metallurgy of aluminum containing much hitherto unpublished matter could be assembled from the citations scattered throughout the book. However, that does not mean that the other metals are neglected; steels take first place in the discussion of hardening, copper alloys in the discussion of cold work and annealing. Many other sections, replete with ideas and data of recent origin, impress the reader with the extraordinary scope of the authors' information.

The junior author comes into his own in the early portion of the section on physical metallurgy, where may be found a discussion of crystal structure, phase changes in the solid state, ordered solid solutions or "superlattices", and the mechanism of precipitation hardening —in all of which the explanations are buttressed with X-ray evidence. Dr. SACHS' hand, in turn, is seen in the discussions on residual stress and in the Teutonic mixture of mathematics and experience in the chapters on rolling, drawing, extrusion and forging of metals. One gathers from the footnotes that his Monograph on Plastic Working (*Spanlose Formung*) is drawn upon heavily for these pages.

Complete though the text may be, it is supplemented by hundreds of references to the periodical literature of the last decade. Two thirds of these are from the American and English, and consequently are easily available and readable by the inquiring student or practitioner who may wish to get some elaboration of the concise facts as stated.

It may be suspected, by now, that the reviewer is enthusiastic about the book as a source of information. As a product of the printer's art, one notes the continued gain in the typographical excellence of books published by the American Society for Metals. About the only criticism in this respect is the uneven reproduction of the line drawings. These apparently were all made for half reduction, but some are larger and some smaller, and sometimes appear in contrast on the same page. A few of the equilibrium diagrams in the appendix also need a glass to be read; however, most metallurgists already own small magnifiers.

*Any* metallurgist would be glad to get this book for a Christmas present. E. E. T.

## New Book on Stainless Steels

THE ALLOYS OF IRON AND CHROMIUM, Vol. II, by A. B. Kinzel and Russell Franks. (One of the Engineering Foundation's Alloys of Iron Monographs.) 559 pages, 6x9¼ in., 133 figures. McGraw-Hill Book Co., New York. Price $6.

Reviewed by HARRY K. IHRIG

The number of books on stainless alloys published is very limited. The excellent works of THUM and MONYPENNY have given much information on these steels. However, the last editions of these were published in 1935 and 1931 respectively, and much new work has been done in this field within the last five years. This book is therefore timely.

"Alloys of Iron and Chromium" is the second volume on iron-chromium alloys and the 11th of the Alloys of Iron Research series. It is a complete work in itself and a new book on stainless steels. However, the first volume on "Alloys of Iron and Chromium" by KINZEL and CRAFTS can be read very profitably. The dividing line between the two is at 10% chromium content, although the preparation of chromium metal and ferrochrome as well as some of the general principles of metallurgy of all chromium alloys are included in Vol. I. This new Vol. II covers the literature to date and also includes much unpublished work of the authors' and other laboratories.

Rapid advancement in research and the commercial production of stainless steels in recent years makes it desirable to have the data summarized critically at frequent intervals. Many of the phenomena found in stainless steels are not completely understood, and numerous changes in manufacture, treatment and use are being made as a result of intensive studies in this field. However, as the authors have pointed out, these alloys are by no means entirely separate or different from carbon or other alloy steels. Taking into consideration the effect of chromium on phase formation and its tendency to promote sluggishness in phase changes, they may be studied by using established metallurgical theory and procedure.

The iron-chromium and the iron-chromium-carbon systems were discussed in detail in the earlier Vol. I and they are summarized and frequently referred to in this Vol. II. Development of these phase diagrams has made possible the rapid increase in knowledge and industrial development of stainless alloys.

Melting and fabrication of commercial products from the ingot is described in the early chapters. For a review of the various properties, subsequent chapters are divided into *(a)* the 10 to 18% chromium, low carbon steels, *(b)* 10 to 18% chromium, medium carbon steels and *(c)* 10 to 18% chromium, high carbon steels. The superior oxidation resistant steels with a chromium content of over 20% and the high chromium cast irons are then discussed.

The last half of the book covers the important family of iron-chromium alloys that contains additional elements. The structural diagrams with nickel, manganese and silicon are summarized. Many pages are then devoted to practical matters—the melting, working and fabricating operations. A discussion of physical and other properties, and the effect of temperature on these, follows. A long chapter is devoted to the oxidation and corrosion resistance of these important industrial metals.

The effect of the addition of various other elements such as silicon, tungsten, molybdenum, titanium, columbium, tantalum, sulphur, selenium and copper on austenitic steels is discussed. The subject of chromium-manganese steels, or such steels with additions of nickel or other elements, is not treated in detail in stainless steel books because of their relatively small use in this country. KINZEL and FRANKS have, however, summarized the literature on these alloys very carefully, and in this rapidly advancing science the chromium-manganese steels may be of increasing importance. For example, at present the manganese content of the columbium and molybdenum type of austenitic steels is being raised to over 1% to give them better workability when hot.

Another class of alloys which ordinarily are not thought of in connection with stainless steels are the iron-chromium-aluminum ones used principally for electric resistance elements. These materials have come into quite general use only in the last few years and, hence, are not usually included in the older stainless steel books; however, they should be and have been by KINZEL and FRANKS.

The book has an excellent bibliography and is well indexed. Both authors and subjects are given. It is clearly written and the various controversial theories are presented from both sides. The reviewer strongly recommends this work to anyone interested in this field and welcomes it as an addition to the general series published by the Engineering Foundation.

## A Handbook on Alloy Cast Iron

ALLOY CAST IRONS, a handbook. Semi-flexible binding, 270 pages, 6x9 in. 111 illustrations. Published by the American Foundrymens Association, Chicago. Price $3.

Reviewed by GARNET P. PHILLIPS

This is the only authoritative, impartial and comprehensive book available on the subject. It was written by the American Foundrymens Association's Gray Iron Division (Alloy Cast Iron Committee) composed of A.F.A. members and representatives of the American Society for Testing Materials, American Society for Metals, American Institute of Mining and Metallurgical Engineers, and the Society of Automotive Engineers. Representatives of alloy producers, alloy cast iron producers, and users worked three years on the project.

The book starts with definitions of plain and alloy cast irons and states the metallurgical principles involved in a study of alloy cast irons. The effect of alloying elements on solidification, graphitization, precipitation and solution reactions, critical transformation and diffusion is discussed as well as the effect of alloying elements on microconstituents and properties.

The qualitative effects of alloying additions on cast iron are given in detail for each alloying element as it modifies the structure, mechanical properties, machinability, wear resistance, heat and corrosion resistance and foundry properties. Attention is called to lack of data where none or but few are available.

The quantitative effects of alloying elements and combinations of alloys on the physical and mechanical properties of gray irons are also covered in detail. The effects of each alloying element, and commonly used combinations, on tensile strength are given first, followed by data on hardness, transverse strength and deflection, compressive, shear and torsional strength, endurance limit, impact strength, machinability, wear, heat and corrosion resistance, mass and section size, electrical and magnetic properties, thermal conductivity and thermal expansion. Interrelationships between tensile strength and other physical properties are shown. The data in this section are complete and particularly valuable to the engineering professions.

A section is devoted to white and chilled alloy cast irons, the data given including the requirements of chilled castings and the effects of alloying additions on physical properties and depth of chill.

The important subject of heat treatment is discussed in detail. Sections are given on stress relief, annealing, hardening, quenching and tempering, air hardening, nitrogen hardening, flame hardening and hot quenching. The relatively new processes of short annealing (malleableizing) of alloy white irons and inverse annealing (hardening) of austenitic alloy irons are described. Typical compositions and resulting physical properties obtained by the various heat treatments are given. One omission is "induction" hardening, which has only recently been applied to plain and alloy cast irons.

One chapter is devoted to the various phases of foundry practice for alloy cast irons. The importance of cooperation between designers of castings and foundrymen is stressed. Shrinkage, machine finish allowance, sectional considerations and design problems are discussed. Molding and core sand properties, their preparation and control, molding methods, mold finishes and gating and risering as well as various melting methods and processes are briefly described. An important section for the foundryman is that on the various ferroalloys available and methods of addition to cast irons both in the furnace and to molten metal during or after tapping from the furnace.

A chapter is devoted to specific applications, classifying the castings according to broad fields of today's application. Each specific application gives the name of the casting, chemical analysis specified, metal section, weight and hardness range, range of transverse strength, deflection and tensile strength, and remarks on service life and reasons for using the particular composition. This section is particularly valuable as a reference for everyone having to do with alloy iron castings.

## Processing of Sheet Metals

THE METALLURGY OF DEEP DRAWING AND PRESSING, by J. Dudley Jevons. 690 pages, 6x9¾ in., 303 illustrations, Chapman & Hall, London, England. Price 50s. (John Wiley, New York, has imported sheets for an American "edition".)

Reviewed by JOSEPH WINLOCK

Many articles and books have been written on the subject of deep drawing from the point of view of die design. For the most part these books give empirical laws and ingeniously con-

ceived methods of producing different desired shapes. But there has long been a need to those engaged in the deep drawing industry for a book that treats the subject from a metallurgical point of view. To this reviewer, who has spent some 20 years in the deep drawing of metals, JEVONS' book satisfies the need. This book, it seems to me, should not only be on the book shelves of all those engaged in deep drawing, but it should be *read* by all those so engaged. It is only by a complete knowledge of *all* the factors involved in a given industry that we can hope to make progress, and a knowledge of the metallurgy of the different metals used in deep drawing is just as important as the design of dies. Each is dependent upon the other.

JEVONS did not write with the intent of expressing new ideas or new methods, but as he states in his preface "to offer in convenient form some portion of metallurgical knowledge bearing directly upon the craft of deep drawing and pressing". This has been very effectively accomplished. That it is elementary in character is not a shortcoming, but an advantage.

The scope of the book is a large one in that it describes the manufacture and rolling of two of the most widely used alloys, namely, steel and brass. For this reason and because the author goes into great detail on many subjects, the book is heavy and cumbersome to hold. It would have been more convenient, then, to have published it in two volumes.

## Plain Chromium Steels

CHROMIUM STEELS, by Richard Henry Greaves. 321 pages, 78 figures, 6x9½ in. Published by H. M. Stationery Office, London, England. Price 7s 6d.

Reviewed by ELMER GAMMETER

In this world of rapidly changing events, in which our metallurgical knowledge is moving with an admirable share, it is difficult to offer a review of a book which includes no reference to any work published later than December 1933. Since this date, other publications have covered this subject with added information and thoroughness.

The title "Chromium Steels" is qualified in the preface by limiting the subject matter to straight chromium steels and avoiding "stainless" steels. Useful chromium steels with additions of nickel, molybdenum, copper, vanadium, tungsten, unfortunately, are not discussed. However some interesting data showing the effects of silicon and manganese on low chromium steels are included.

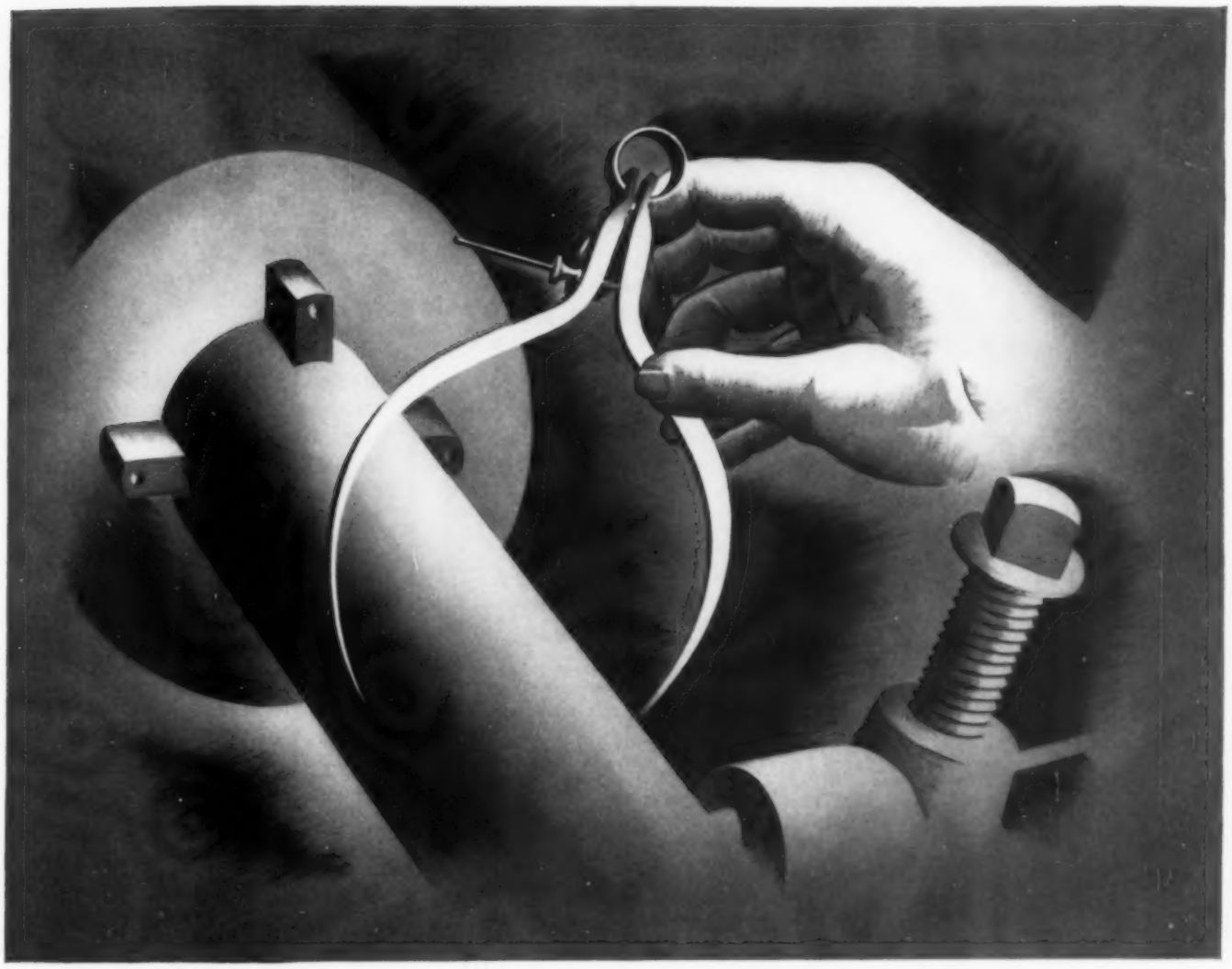
The book is essentially an extensive review of the constitution of the iron-chromium, chromium-carbon, and iron-chromium-carbon systems, information on the heat treatment and uses of the plain low chromium steels, and considerable data covering their physical and mechanical properties. The subject matter, in general, is indicative of considerable laboratory investigational work, as well as extensive searches of the literature. The regular subject index, which is somewhat scant, is supplemented by a special index to physical properties which improves its value as a reference work. To American readers the data on the physical properties of steels of specific analyses should be of considerable value.

## Important Trade Publications

INDUSTRY is belatedly alive to the necessity for training mechanics. Lecture notes, bench experiments and textbooks for apprentices and beginners in the various trades are much in demand. Especially timely, therefore, are the four small volumes on **Welding** recently issued by Air Reduction Co. (8½x11-in. page size) containing detailed notes for 20 lectures and 22 exercises in oxy-acetylene welding and 20 lectures and 30 exercises in arc welding.

LINCOLN ELECTRIC CO. has also published in 5½x8½-in. page size a more comprehensive book of 50 lessons on arc welding based on the experience of ARTHUR MADSON in the company's own welding school.

MAGNETIC TESTS indicated too many unimportant variables in metallic parts to become commercially useful until Messrs. DE FOREST, MCCUNE, BETZ and DOANE started to promote the "magnaflux" method. The steel object is magnetized and immersed in magnetic powder, whereupon tiny cracks at or near the surface are marked by accumulations of the dust. In a decade the process has become universally used for inspecting parts for high speed equipment, and for searching for incipient fatigue cracks in aircraft engine parts during the 500-hr. overhauls. In **"Principles of Magnaflux Inspection"**, F. B. DOANE now presents a very useful account of the process, containing much unpublished information. Especially noteworthy is the discussion of threshold indications, and the methods for demagnetization (when such is necessary).



# WHEN PRECISION GUARDS PRECISION

It is an old saying that "it's a poor workman who blames his tools". But shop foremen know that even the best operator cannot turn out precise and well finished work on a lathe with worn or faulty headstock gears.

To make sure of maintained accuracy at this vital spot, a well-known lathe maker has standardized on carburized Nickel-Molybdenum steels — using SAE 4815 for drive gears and SAE 4615 for the transmission gears.

These two Molybdenum steels, in addition to having the requisite core strength and toughness, carburize to 55-60 Rockwell "C" with minimum distortion. Consequently proper initial adjustment is simple and freedom from trouble due to worn teeth is assured for an extended service period. Thus precision guards precision for years.

Rechecking your own specifications may disclose opportunities for increasing serviceability of the product by a change in materials. You will find our book, "Molybdenum in Steel", helpful. It is sent free on request.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

**Climax Mo-lyb-den-um Company**
**500 Fifth Avenue · New York City**

MOLY

# Personals

**H. P. Langston** is employed in the metallurgical laboratory, Springfield Armory, Springfield, Mass.

**Donald M. Yenni** is employed by The Linde Air Products Co. as metallurgical engineer in the Tonawanda, N. Y., research laboratory.

**A. A. Archibald**, formerly metallurgical engineer attached to the general office of the Jones & Laughlin Steel Corp. in Pittsburgh, has been transferred to the sales department, Philadelphia office.

**James H. Moore**, B.S. in metallurgy, Massachusetts Institute of Technology, is employed as a metallurgist by the Aluminum Co. of America, New Kensington, Pa.


TYPICAL PARTS HEAT TREATED IN HOLCROFT *CONTROLLED ATMOSPHERE* FURNACES

**CARBO-NITRIDING:**
Valves, Ball Caps (Universal Joint Housings), Cylinder Liners, Ball Studs, "U" Bolts, Stampings, Gears.

**GAS-CARBURIZING:**
Transmission Gears, Chain Sprockets, Ring Gears, Pinions, Truck Gears.

**CLEAN HARDENING:**
Gears, Axles, Clutch Spring Plates, Cam-shafts.

**CLEAN ANNEALING:**
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**SHORT CYCLE MALLEABLE ANNEALING:**
Miscellaneous Automotive Castings, Pipe Fittings, Agricultural Implements, Tractor Parts.

*Special Note*

**DEFENSE PRODUCTION**

Furnaces available for every armament requirement. Many of the above furnaces can be adapted to handle munitions and armament. Write, wire or telephone your nearest Holcroft engineer for details.

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BUILT BY HOLCROFT & COMPANY DETROIT-MICH.


**Robert P. Sitzer**, formerly with Corrigan McKinney Steel Division, Cleveland, is at present an employee of Northrop Aircraft Co., Hawthorne, Calif.

**P. E. Landolt** is president and **H. Osborg** vice-president and treasurer of the newly formed Lithaloys Corp., New York.

Elected vice-president of the American Institute of Mining and Metallurgical Engineers: **Paul D. Merica**, vice-president, International Nickel Co. of Canada, Ltd., New York. **Clyde E. Williams**, director, Battelle Memorial Institute, Columbus, Ohio, has been elected a new director of the Institute.

**R. A. Karr**, formerly at the Central Alloy Division of Republic Steel Corp., has been appointed metallurgist for Copperweld Steel Co., Warren, Ohio.

**Russell G. McMillen**, Carnegie Institute of Technology, 1940, is at present engaged in development work on aircraft cylinder heads for the Aluminum Co. of America in Cleveland.

**Dolph G. Ebeling** is now in the metallurgical department, Homestead plant, Carnegie-Illinois Steel Corp.

**Leonard E. Mierzwa** is now a tool designer at Lockheed Aircraft Corp., Burbank, Calif.

Transferred by Carnegie-Illinois Steel Corp.: **Ralph D. Webb, Jr.**, from the metallurgical laboratory at the Gary Works to the Chicago district office as a metallurgical contact representative in the structural and plate bureau.

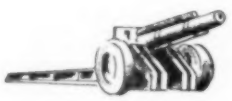
**N. K. Koebel**, formerly with Eastman Kodak Co., is now in the research department of Lindberg Engineering Co., Chicago.

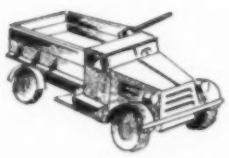
**J. D. Wilfong, Jr.**, sales and service engineer for Magnetic Analysis Corp., has been transferred from the Ohio to the Pittsburgh district.

**David L. Ellis** has left Greenfield Tap and Die Corp. to take up graduate studies in metallurgical engineering at the University of Wisconsin.

# Minute Quiz

## FOR MANUFACTURERS OF DEFENSE EQUIPMENT





| QUESTION | ANSWER |
|---|---|
| How can I tool up faster and operate with less replacement delay? | Make your tools and dies of Graphitic Steel. |
| What is it? | Graphitic Steel contains free Graphite. There are three grades —Graph-Sil, Graph-Mo, and Graph-Tung. |
| What properties does it have? | It combines the free machining qualities, high resistance to wear and good frictional properties of cast iron, with the high strength, uniform structure and ready response to heat-treatment of steel. |
| Into what sections can it be worked? | Rounds, squares, flats, hexagons, sheet, strip, seamless tubing, weldless rings, forgings of all kinds. |
| What are the Machining Properties in the annealed condition? | Graph-Sil and Graph-Mo are remarkably free cutting, with the short chip and smooth finish that are the properties of cast iron. Graph-Tung has these properties, too, notwithstanding its higher Brinell hardness. |

Write for new 16-page Graphitic Booklet. It shows 24 specific Graphitic Steel Applications.

**THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO**
**Steel and Tube Division**

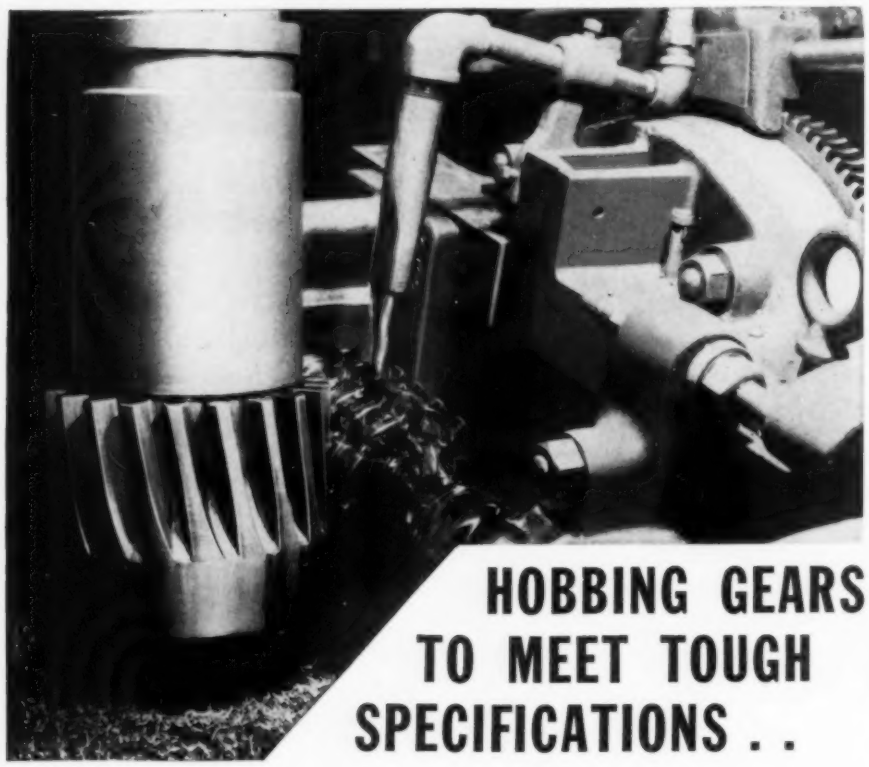
# Personals

**A. T. Greiner,** formerly in charge of Salem Engineering Co.'s work in France, and **Thomas Breene**, associated with Salem Engineering Co., Ltd., London, have returned to the U.S. and are now in the sales department, Salem Engineering Co., Salem, Ohio.

**Eugene Sunnen**, graduate of Michigan State College, is now employed by Carboloy Co., Inc.

**Richard K. Lee**, formerly with Timken Roller Bearing Co. in Canton, Ohio, is now with the McKay Chain Co., York, Pa.

**W. B. Scott**, formerly metallurgist and plating engineer for Metals Refining Co., Hammond, Ind., is now metallurgist and sales engineer for Ampco Metal, Inc., Milwaukee.

**HOBBING GEARS TO MEET TOUGH SPECIFICATIONS . .**

HOBBING gears of extreme hardness (325—350 Brinell) as used in oil well pumping reducers—for particularly arduous duty—was the problem of a Chicago manufacturer. In cutting and maintaining this unusual hardness and maintaining high accuracy, Cities Service oils were used as the cutting lubricant.

No doubt you have one or two like problems in your shop. Why not find out what our lubrication engineers can do for you in your own shop with the right metal cutting lubricant? Just write us to have a lubrication engineer call.

Copies of our booklet on "Metal Cutting Lubrication" are available to users of metal cutting lubricants. Write for your copy today, before the supply is exhausted.

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"SERVICE PROVED"

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Sixty Wall Tower, Room 1626F, New York

Please send me information concerning your Lubrication Engineers' Service ☐

Please send me booklet on Metal Cutting Lubrication ☐

Name ..... Title .....

Business Address .....

Firm Name .....

City ..... State .....


**Thomas G. Harvey** has completed the work for a Master's degree in metallurgy at the University of Wisconsin, and accepted a position as metallurgical engineer with the Monarch Steel Co. in Indianapolis, Ind.

**Donald E. Babcock** has left Mellon Institute of Industrial Research and the Pittsburgh Steel Co. to become head of the chemical engineering research laboratories of the Owen-Corning Fiberglas Corp.

**Benjamin Falk**, a graduate of University of Michigan, is now employed by Simonds Saw and Steel Co., Lockport, N. Y.

**Gladstone C. Hill** is now head of sales training for Carnegie-Illinois Steel Corp.

**Joseph J. Link, Jr.**, formerly a student at Carnegie Institute of Technology, is now taking the "loop course" with Bethlehem Steel Co., in the metallurgical department at the Sparrows Point Plant.

**Clyde Llewelyn**, formerly sales engineer for Bliss & Laughlin, Inc., is now in Government work in Washington, contacting the National Defense Council and various Government agencies in connection with the defense program.

**Ernest G. Beck**, formerly metallurgist with the Landis Tool Co., is now sales manager and assistant manager of the foundry division of H. W. Butterworth & Sons Co., Bethayres, Pa.

Appointed by Universal-Cyclops Steel Corp.: **W. P. Knecht**, formerly with Crucible Steel Co. of America, to district sales manager at Worcester, Mass. **W. J. Long**, former manager, has been transferred to the executive offices at Bridgeville, Pa.

**Fred A. Endress**, formerly with the Signode Steel Strapping Co., Chicago, is now chief metallurgist at Tuff-Hard Corp., Detroit.

**Henry P. George**, graduate student at Carnegie Institute of Technology, is now instructor in metallography and process metallurgy at the University of Detroit.

# Bombs MUST BE TREATED WITH CARE

Modern bombs no longer resemble the round, cannonball type we associate with revolutionists—but regardless of size or shape they must be heat treated exactly and uniformly to meet purchasers' requirements.

To insure quick, easy heat treating of bombs and other munitions, Flinn & Dreffein have designed their standard chain furnace so that it can be changed over to handle work in a few hours.

Other Flinn & Dreffein furnaces can be quickly adapted to this work, putting into action the engineering knowledge accumulated during the first World War. If you want heat treating furnaces designed to handle the heat treatment of bombs and other munitions on a production basis, investigate the Flinn & Dreffein service today.

Typical Flinn & Dreffein furnaces include: annealing . . . billet heating . . . bright annealing . . . controlled atmosphere . . . carburizing . . . scale-free annealing . . . drawing . . . short cycle malleable annealing . . . forging . . . hardening . . . normalizing . . . continuous conveyor furnaces for sheet mills . . . continuous normalizing furnaces for sheet mills.

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INDUSTRIAL FUEL EQUIPMENT
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CHICAGO, ILL.

**FLINN & DREFFEIN**
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308 WEST WASHINGTON ST., CHICAGO, ILLINOIS

# Personals

**John J. Dale** is now employed as a metallurgist, grade I, at the Munitions Supply Laboratories, Maribymong, Victoria, Australia.

**Albert R. Stargardter** is now chief metallurgist of Eastern Rolling Mill Co., Baltimore, Md.

**C. A. Liedholm**, formerly assistant metallurgist, Jessop Steel Co., is now with Curtiss-Wright Corp., at the Neville Island Plant, Pittsburgh.

Named chairman of the Anti-Aircraft Artillery Carriage Committee: **Joseph L. Auer**, general works manager of R. Hoe & Co.

**Joseph J. Repko**, formerly metallurgist at Vlchek Tool Co., Cleveland, is now metallurgist for Detroit Bevel Gear Co., Detroit.

Quick engineering and delivery service available at all principal metal working centers.


**Donald B. Oakley** and **Leslie G. Probst**, who recently finished Bethlehem Steel Corp.'s "loop course", are now in the metallurgical department at the plant in Bethlehem, Pa.

**Dan White**, formerly with Goss Printing Press Co., Chicago, is now with the National Advisory Committee for Aeronautics, Langley Field, Hampton, Va.

**Major John H. Frye** has been granted leave of absence by Columbia Steel and Shafting Co. and the Edgar T. Ward's Sons Co., where he served as metallurgical engineer and metallurgical consultant, and has been commissioned in the Ordnance Reserves and placed on active duty in the Engineering and Development Section of the Ordnance Department, Washington, D. C.

Appointed by the National Academy of Sciences as a committee to plan the recovery of manganese from low grade domestic ores: **James H. Critchett** of Union Carbide & Carbon Corp.; **Charles H. Herty, Jr.** of Bethlehem Steel Co.; **John Johnston** of U.S. Steel Corp. Research Laboratories; and **Gilbert Seil** of E. J. Lavino & Co.

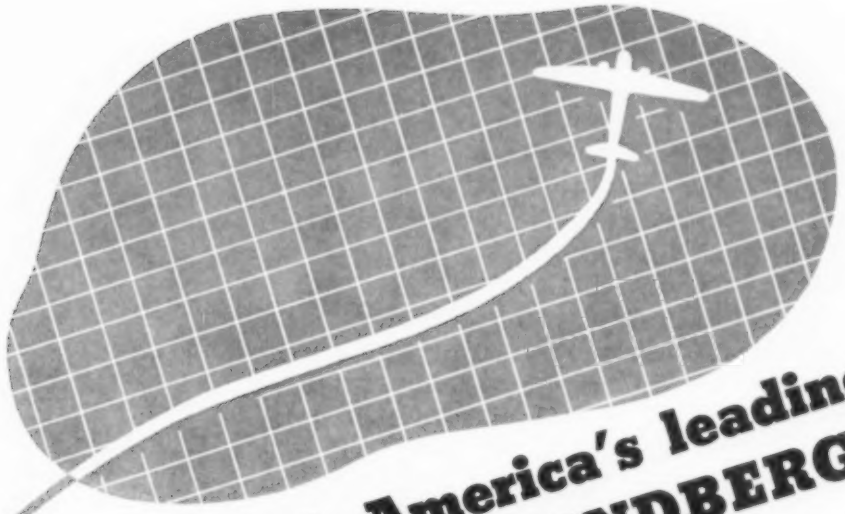
**John T. McGrath**, formerly metallurgist at the Fitchburg plant of Simonds Saw and Steel Co., is transferring to the Newport, R.I., Naval Torpedo Station as metallurgist.

Promoted by Jones & Laughlin Steel Corp.: **C. M. Lichy**, from metallurgical engineer in the Detroit area to assistant metallurgist of the Pittsburgh works.

**Robert S. Busk**, doctor of engineering, Yale University, has started work with Dow Chemical Co. as metallurgist.

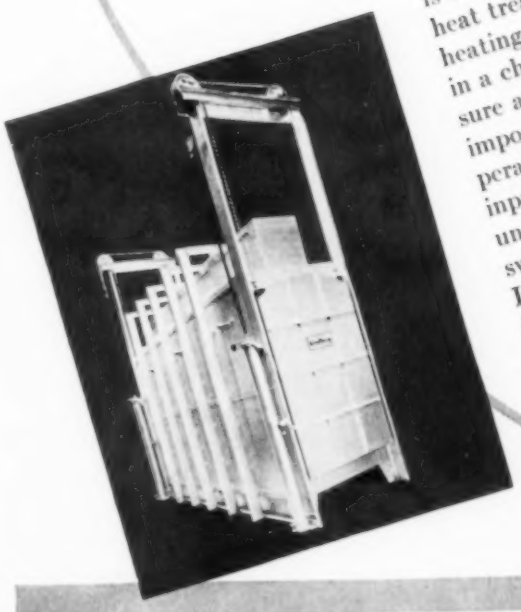
**Harry J. Starke** has been appointed sales representative of William Jessop & Sons, Inc., Chicago, as assistant to District Manager **Thorvald L. Haines**.

**Evan F. Wilson**, formerly metallurgist of the Frontier Bronze Corp., is now metallurgical engineer and assistant to **H. J. Kerr**, executive assistant of Babcock and Wilcox Co.



# Over 90% of North America's leading aircraft manufacturers now use LINDBERG Cyclone Tempering Furnaces!

YES, *it is significant that 9 out of 10 leading North American aircraft manufacturers use Lindberg Cyclone Tempering Furnaces* . . . for today, more than ever, both commercial and defense aviation demand, in heat treating, the utmost in accuracy, control, and speed. Increasingly important has become military accuracy in swift mass production. For this reason aircraft manufacturers everywhere look to Lindberg for tempering accuracy—for well they know that each and every portion of every charge, whether it be landing gear forgings, aluminum sub-assemblies, or the smallest rivet, must be heated to precisely uniform temperatures if the peak of strength is to be reached. ✶ The secret of the Cyclone's tremendous success in heat treating aircraft parts is in the unique Cyclone forced convection heating principle by which great volumes of air are accurately heated in a chamber separate from the work chamber and forced under pressure at 2-mile-a-minute velocity to all parts of the charge—making it impossible for temperature differences to exist. ✶ Supplementing temperature uniformity, the Lindberg Control accurately apportions heat input, eliminating heat supply surges or deficiencies, and the resulting undesirable jagged control curves. ✶ Where high military accuracy in swift mass production is demanded, you can definitely depend on the Lindberg Cyclone Tempering Furnace. A special bulletin, "*Heat Treating Furnaces for the Aircraft Industry*," has been prepared and is available on request. Lindberg Engineering Company, 222 North Laflin St., Chicago.



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## LINDBERG FURNACES

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# Smelting Low Manganese Ore

By C. E. Wood, E. P. Barrett and P. R. Porath

*Extracts from Bureau of Mines Report of Investigation 3545, November 1940*

A LARGE TONNAGE of manganese exists in the "black" and "brown" manganiferous iron ores of the Cuyuna range in Minnesota. They contain 15% manganese and 30 to 45% iron. Mangano-siderite with 14% manganese and 23% iron is also available from mines in Leadville, Colo. A similar carbonate ore from Chamberlain, S. D., contains 16% manganese and 14% iron and is higher in phosphorus. The experiments described were undertaken to determine whether a simple smelting to a sulphide-oxide matte would produce an intermediate product that could be roasted and then contain the 7 to 1 manganese-to-iron ratio required by Federal specifications for ferro-grade ore.

Pyrite, the common sulphide of iron, was added to the charge to supply the sulphur. When any of these ores, pyrite, coal for a reducing agent, and the necessary fluxes are melted together, three products are obtained—namely, metal, matte, and slag, which separate easily into three liquid layers according to their density.

A large number of crucible melts indicate that the matte will contain 50 to 55% Mn, 3 to 8% Fe, and 33 to 35% S. The phosphorus is found in the metal rather than in the matte. Such a matte can be roasted in the standard equipment in copper smelters, into a calcine containing 2 to 3% sulphur. The most of the remaining can then be eliminated by sintering, in the same manner that high sulphur iron ores containing gypsum have been treated before use in the blast furnace. In addition to reducing the sulphur to a low value, sintering would improve the structure of the ore, especially for blast furnace use. The sinter would then be rich enough in manganese and low enough in sulphur to be smelted into ferromanganese in the regular manner. However, reduction tests should be made to determine whether ferromanganese that would meet the sulphur specification of not over 0.05% could be made without sintering the roasted matte.

Blast furnace men recognize the importance of basicity of slag in controlling the manganese lost to the slags. In the smelting of these low manganese ores to matte, the same is true. Recoveries in the matte ranged from 57% when there was 18% of limestone on the charge to 77%

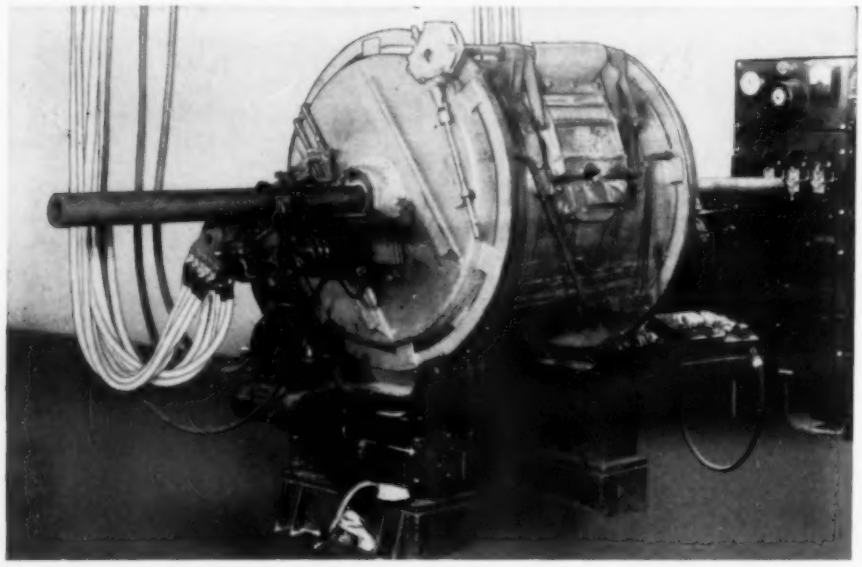
**Eliminate the Bottleneck**

**IN YOUR FOUNDRY PRODUCTION...**

There's no longer any need for a foundry to hold up production waiting for enough tonnage of the same type of metal. For with a Detroit Rocking Electric Furnace small heats as well as large can be run economically—any number of hours per day. In either a ferrous or non-ferrous foundry a variety of mixes can be melted, changing the alloy on successive heats throughout the day if desired. A Detroit Electric Furnace is a proven METALLURGICAL TOOL to obtain superior quality at lower cost. And as a UTILITY TOOL it is unequalled in the foundry industry.

Write today for further facts on how a Detroit Rocking Electric Furnace means added profits for you.

Type LFY—500 lb. rated capacity Detroit Furnace. (Holds 1250 lbs. of molten bronze or iron)



**DETROIT** ELECTRIC FURNACE DIVISION

KUHLMAN ELECTRIC COMPANY • BAY CITY MICHIGAN

when there was only 6%. Up to 9% calcium sulphide is found in the mattes produced under the most acid slags.

The composition of the slag most suitable from the standpoint of recovery of manganese and formation of matte is much more acid than that of normal blast furnace slags, but slags approaching this composition have been produced in charcoal furnaces making high silicon foundry iron. Low fusion point and high viscosity characterize these extremely acid slags. In laboratory tests replacement of about half the CaO with $Na_2O$ has been found to expedite matte and slag separation by lowering the free-running temperature of both the slag and the matte. The increased cost of producing a slag that contains 8 to 10% $Na_2O$ might be more than offset by increased recovery of manganese in the matte. The $Na_2O$ can be added as soda ash or as sodium sulphate; when added as sodium sulphate it would furnish part of the sulphur for the charge.

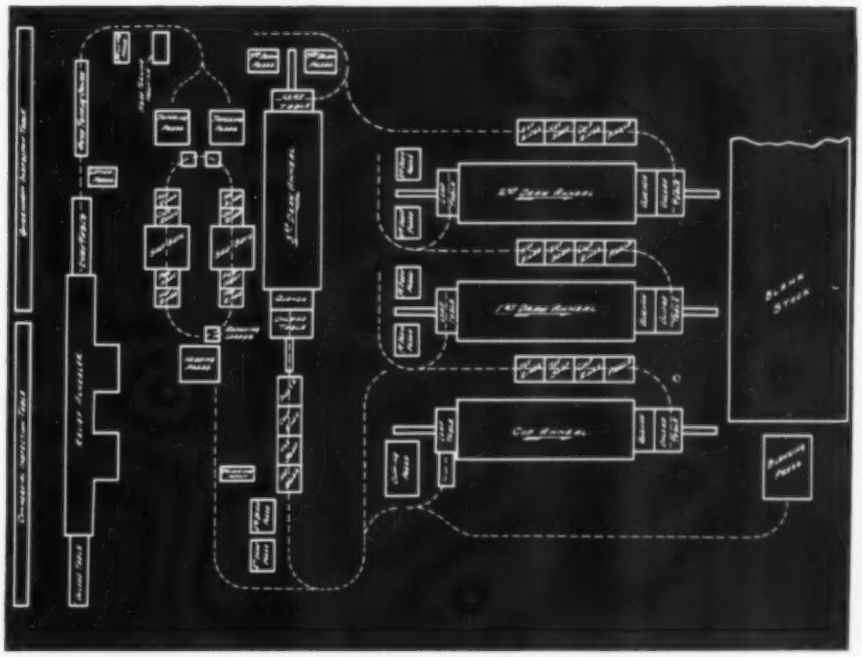
It is also desirable to have the maximum amount of iron sulphide in the matte, as it counteracts the effect of calcium sulphide and lowers the free-running temperature. However, the requirements of high manganese, low iron in the product limit the amount of iron sulphide that can be carried.

Both of the large-tonnage Minnesota ores contain but small amounts of lime and magnesia, and could readily be smelted into the acid slag required for a good recovery of manganese. The brown ores also contain about half as much alumina as silica. As a ratio of $SiO_2$ to $Al_2O_3$ of 3.5 to 4 appears desirable in the slag, and the brown ores contain silica and alumina in the approximate ratio of 2 to 1, they could be smelted more efficiently if mixed with the low alumina black ores.

Laboratory smelting tests on a mixture of 667 parts black ore to 333 parts brown ore, together with 240 parts of pyrite, 70 parts of calcium carbonate, 70 parts of soda ash and 200 parts of charcoal gave 219 parts of a matte containing 52% manganese, 3% iron and 32% sulphur. Recovery of manganese in the matte was 74% of that in the charge. The best of similar tests on the Leadville and the Chamberlain ores gave mattes of nearly the same composition and manganese recoveries ranging from 73 to 75%.

Larger scale tests are necessary to determine the most satisfactory type of furnace in which to matte smelt manganese. The further tests would giver more accurate data on the recovery of manganese in matte and metal, and on the cost of treating a variety of ores.


# What Do You Know
## About Making Shell Casings?



This drawing shows one of many plant layouts for economical shell casing manufacture.

## Let Us Tell You What We Know

If your present equipment and furnaces can be adapted to this work, we will tell you so—and show you how. If you need new equipment and furnaces, we will show you the results of our experience in building this type of equipment for others.

Write, wire or telephone today for CONTINENTAL information on shell casing manufacture—no obligation.

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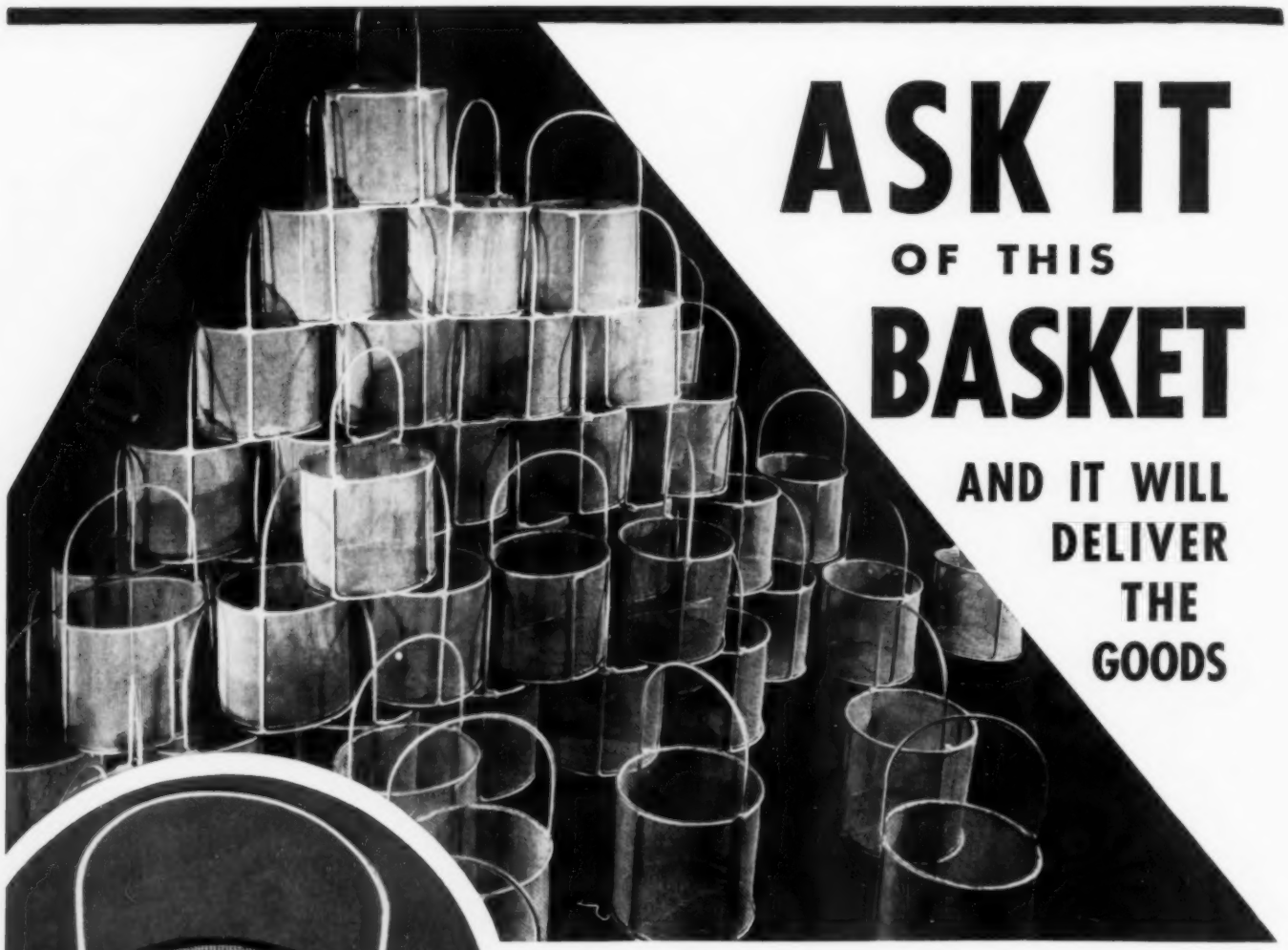
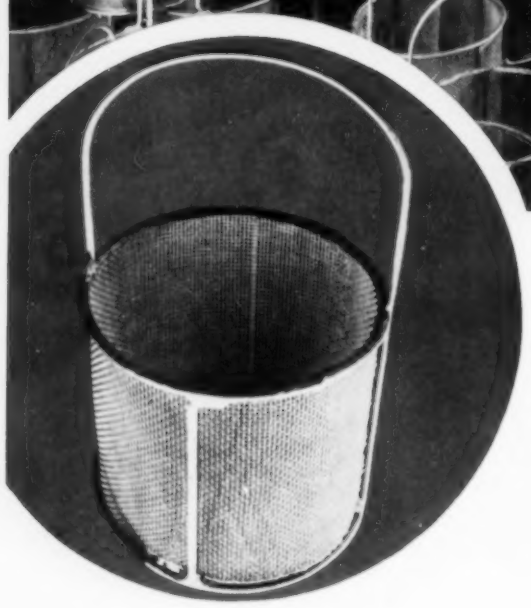


# ASK IT OF THIS BASKET

AND IT WILL DELIVER THE GOODS



THESE baskets were made by Rolock, Inc. out of our Chromel and sold to one of the largest plating works in the country. They replaced baskets made of rubber. The customer bought one to try out . . . and bought 98 more within the year. The Chromel alloys are resistant to corrosion and high temperature oxidation. They are supplied in cast form and are also hot-rolled into flats, rounds and squares. They can be machined and welded. They have good hot-strength. Chromel is melted in high frequency furnaces which assure control of composition. If you have a heat or corrosion problem, we invite you to let us cooperate with you. . . . Hoskins Manufacturing Company, Detroit, Michigan.

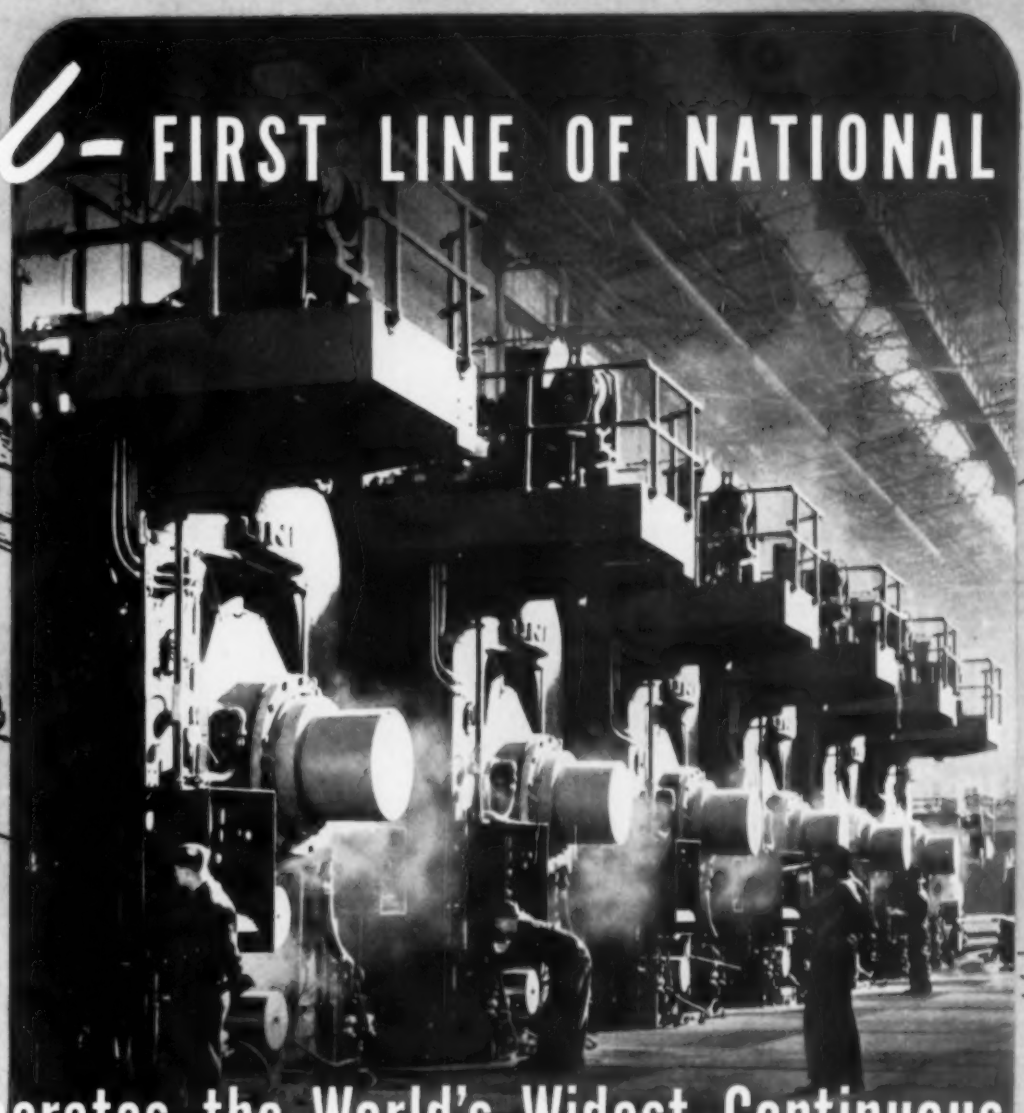
*All our alloys are heat and corrosion resistant. They are useful in many applications but, of course, not all. Our design suggestions often save the customer money. If you have a "hot" problem, tell us about it; if it's heat resistance or electric heating, we likely can help you.*

## HOSKINS PRODUCTS

ELECTRIC HEAT TREATING FURNACES • • HEATING ELEMENT ALLOYS • • THERMOCOUPLE AND LEAD WIRE • • PYROMETERS • • WELDING WIRE • • HEAT RESISTANT CASTINGS • • ENAMELING FIXTURES • • SPARK PLUG ELECTRODE WIRE • • SPECIAL ALLOYS OF NICKEL • • PROTECTION TUBES

Chromel HEATING ELEMENT WIRE

# *Steel*— FIRST LINE OF NATIONAL DEFENSE



## Republic Operates the World's Widest Continuous Strip Mills

The 98-inch hot and cold strip mills in the Cleveland plant of Republic are the widest, fastest and most modern continuous strip mills in the world. Steel rolls from these mills at a speed of 24 miles an hour—up to 91 inches in width—in a wide range of analyses and finishes—to be coiled or cut into sheets.

These mills, completed three years ago to serve the peacetime needs of America, gave to automotive manufacturers, tank makers and other fabricators finely-finished sheets wider than ever before were available—helped speed the making and cut the production costs of many products.

Today, these mills are rolling huge quantities of steel—sometimes as much as 4000 tons in a single day. And now, in these mills along the lazy Cuyahoga River and far from scenes of conflict, more than two thousand men who know steel work in safety to insure the comfort and progress of America—and its greater security.

Yet this is only one of the many improvements in plant facilities made by Republic that will help our country in any national emergency when the need is paramount for more and better ***steel—first line of national defense.***

*The line of steels and steel products manufactured by Republic is so diversified that we have prepared a complete listing in Booklet No. 199. A copy will be sent you upon request.*

**REPUBLIC STEEL CORPORATION • CLEVELAND, OHIO**

**Berger Manufacturing Division • Niles Steel Products Division • Steel and Tubes Division • Union Drawn Steel Division • Truscon Steel Company**

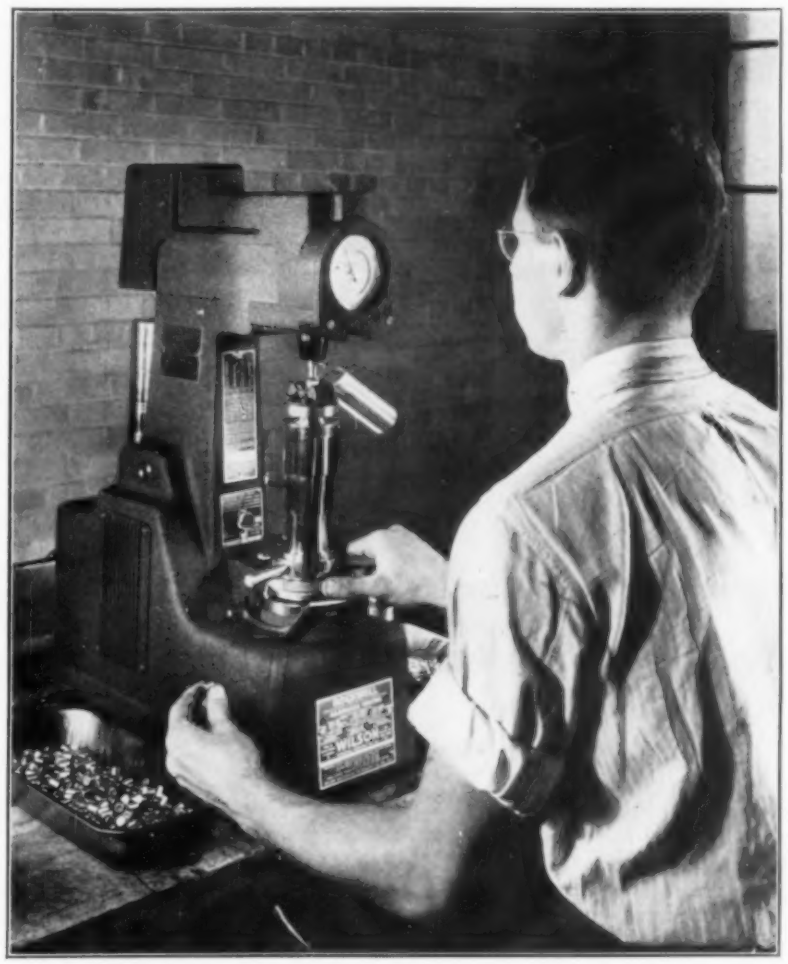
# "ROCKWELL"
## HARDNESS TESTER

**Here is a case where the doctor *does* take his own medicine. We, of course, use a "ROCKWELL" Hardness Tester for testing our own parts.**

**WILSON**
**MECHANICAL INSTRUMENT CO., INC.**

379 Concord Avenue, New York

# "ROCKWELL"
## *Motorized*
## HARDNESS TESTER



**Here, before shipment, we are testing the operation of one of our Motorized Machines destined for quantity inspection testing.**

**379 Concord Avenue, New York**

**WILSON**
**MECHANICAL INSTRUMENT CO., INC.**

## Speed production in your plant with modern GAS equipment

Under the pressure of today's demand for a faster tempo in industrial production, new bottlenecks often emerge—bottlenecks that restrict production flow, make delivery dates a nightmare and limit sales and profit possibilities.

If the bottleneck in your plant is in your industrial heating equipment, it may well be that Gas and the latest type Gas equipment can solve your problem.

For Gas is today's fastest fuel. It cuts heating-up time and reduces firing time cycles. It is above all else flexible and adaptable to any production need. Accurately controllable as to both temperature and furnace atmosphere, it lends itself readily to high speed precision manufacture. It saves storage space, labor and handling costs, and in countless installations is proving itself today's most versatile fuel.

No matter what your industrial heating problem may be, it will pay you to investigate Gas and modern Gas equipment. Your Gas Company will be glad to show you how Gas can step up your own production and, if you wish, give you facts on how other companies in your line have used Gas equipment to solve specific problems in manufacturing.

**AMERICAN GAS ASSOCIATION**
INDUSTRIAL GAS SECTION . . . 420 LEXINGTON AVE., NEW YORK CITY

## MORE PROOF

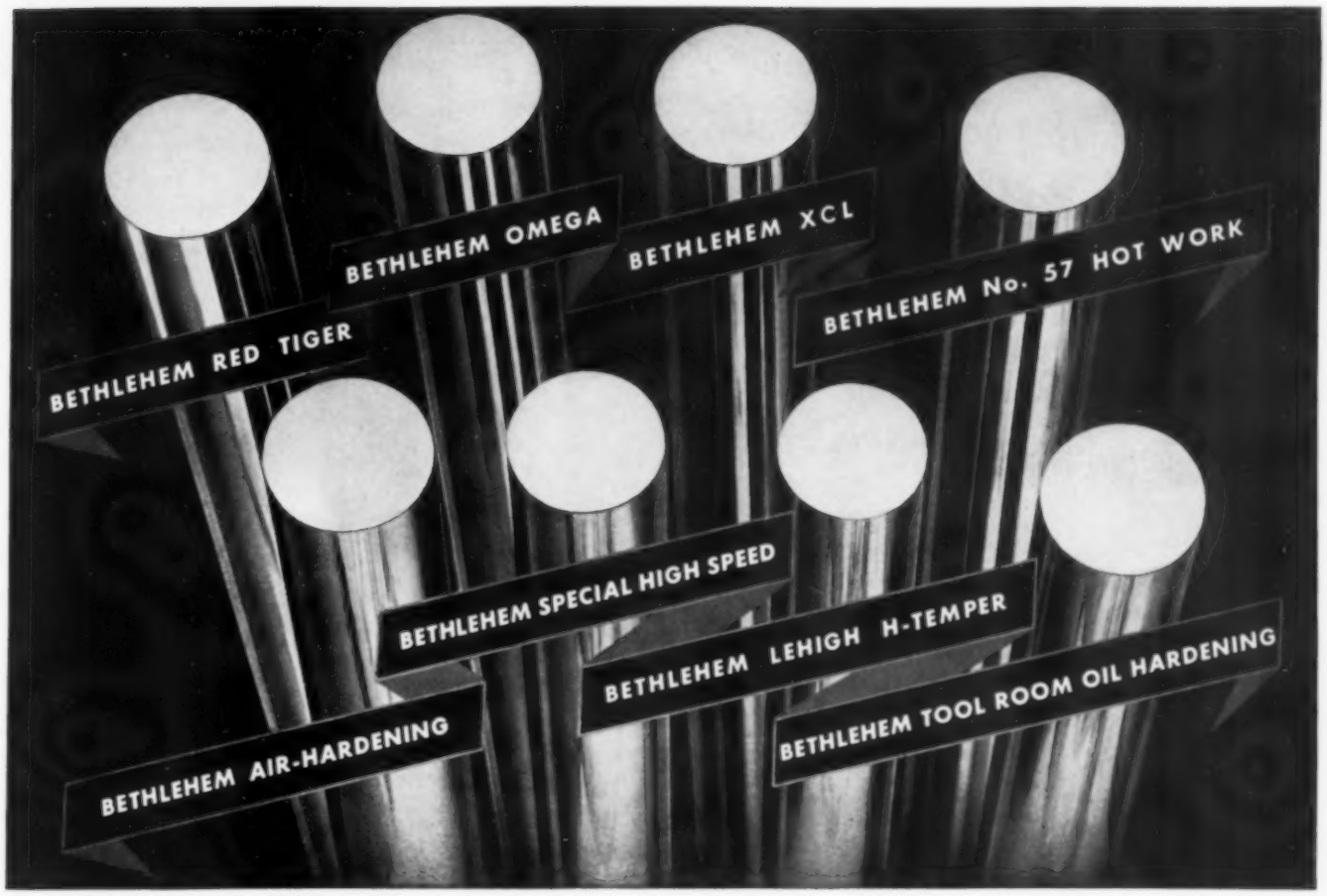
### that GAS speeds production, improves quality, cuts costs.

Gas in the furnace means finer work at the forge. For instance, the gas-fired forge furnace in the plant of the **Frink Corporation,** Long Island City, New York, is making it possible to hold finished forgings to closer dimensions, reduces over-heating, and prolongs the life of forging dies. Thus production steps up while unit costs come down.

For another large industrial plant in the East, Gas has cut the annealing cycle from 7 days to 30 hours. This has been possible through the installation of a continuous controlled atmosphere malleableizing furnace heated by means of gas-fired radiant tubes. The tubes supply the heat for castings which are protected from decarburization and scaling by a prepared atmosphere. The elimination of heavy pots formerly used has resulted in the reduction of the annealing cycle.

Modern improvements in Gas equipment are bringing new economies for all heat treating processes which require delicate and accurate control in a narrow spread of temperature limits.

Investigate what Gas can do for your production—regardless of the size of your plant.




# 8 TOOL STEELS YOU SHOULD KNOW

Here is Bethlehem's complete 8-steel tool kit. Each steel is thoroughly shop-tested. Each handles a wide range of metal-working jobs. Taken together, these 8 fine tool steels will handle 90 per cent of all the work in any plant.

**1. Omega**—A shock-resisting tool steel suitable for pneumatic chisels, calking tools, heading tools, punches and so on.

**2. XCL**—A carbon tool steel that is adapted to virtually every application where quality carbon steel is used.

**3. No. 57 Hot Work**—A tool steel with outstanding heat-resisting qualities, No. 57 retains its strength and hardness through all temperature ranges up to dull red heat.

**4. Lehigh H-Temper**—A high-carbon high-chromium die steel used in punches, taps, master tools, slitting cutters, forming and bending rolls and a host of similar applications. Especially adapted for use in long-run dies and tools.

**5. Special High Speed**—A general purpose 18-4-1 high-speed steel recommended for lathes, planers, boring mills, slotters, shapers, drills, hobs, and many other similar applications.

**6. Tool Room Oil Hardening**—This steel offers good non-deforming qualities and is unusually tough and hard. Recommended for general-purpose die work.

**7. A-H**—Bethlehem Air Hardening (A-H) die steel possesses remarkable non-deforming characteristics, and can be economically heat-treated and handled.

**8. Bethlehem Red Tiger**—This steel, while relatively new, has already set performance records in some of America's leading plants. Recommended for heavy rough cuts or fine finishing operations. High hardness coupled with lack of brittleness, means that Red Tiger is an excellent general purpose steel.

Why not try the 8-steel tool kit in your own shop? Its use reduces inventories, simplifies heat-treatment and improves the quality of finished products. Write to Bethlehem Steel Company, Bethlehem, Pa., for complete details on the money-saving 8-steel assortment.

**BETHLEHEM STEEL COMPANY**

BETHLEHEM STEEL

# TO YOU WHO WORK

*with*

# IRON AND STEEL

As America arms for defense and production climbs upward you who work with iron and steel know the importance of production control.

As important as the metal itself are the essential acids and chemicals necessary for the production and working of metal. Du Pont chemicals are produced to rigid specifications which provide a quality and uniformity of product consistent with your own critical requirements.

With over a century of experience in meeting the needs of the Iron and Steel Industry Du Pont's Grasselli Chemicals Department is again ready in time of emergency to meet the demands of industry with every resource it can muster.

ACIDS • FLUXES • INHIBITORS • CLEANERS • ZINC

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**E. I. DU PONT DE NEMOURS & COMPANY (INC.)**

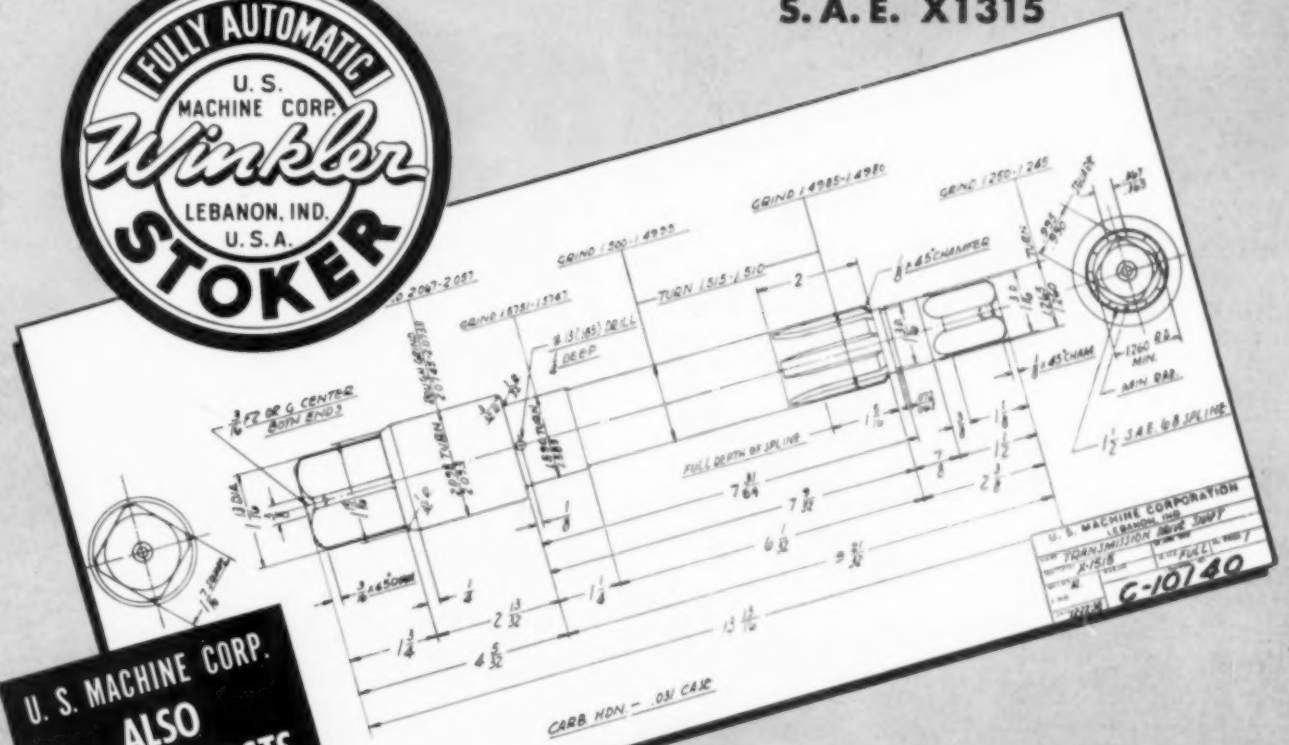
GRASSELLI CHEMICALS DEPARTMENT WILMINGTON, DELAWARE

*. . Run On the Same Equipment*

# SPEED CASE STEEL

## Increased Production 66% Compared With S.A.E. X1315

FULLY AUTOMATIC
U. S. MACHINE CORP.
Winkler
LEBANON, IND. U.S.A.
STOKER




U. S. MACHINE CORP. ALSO REDUCED COSTS $20.73 PER TON OF STEEL USED ON STOKER TRANSMISSION SHAFT

## SPEED CASE STEEL X1515

. . . is a Low Carbon Open Hearth Case Carburizing Steel that *Machines Like S.A.E. X1112 • Carburizes Like S.A.E. X1020 • Physical Properties High • Shock Value Excellent • Unusual Ductility* • It Will Increase Your Production and Lower Your Costs.

***Ask for Sample for* TEST RUN!**

*Sole Licensee for Eastern States*

## THE FITZSIMONS COMPANY

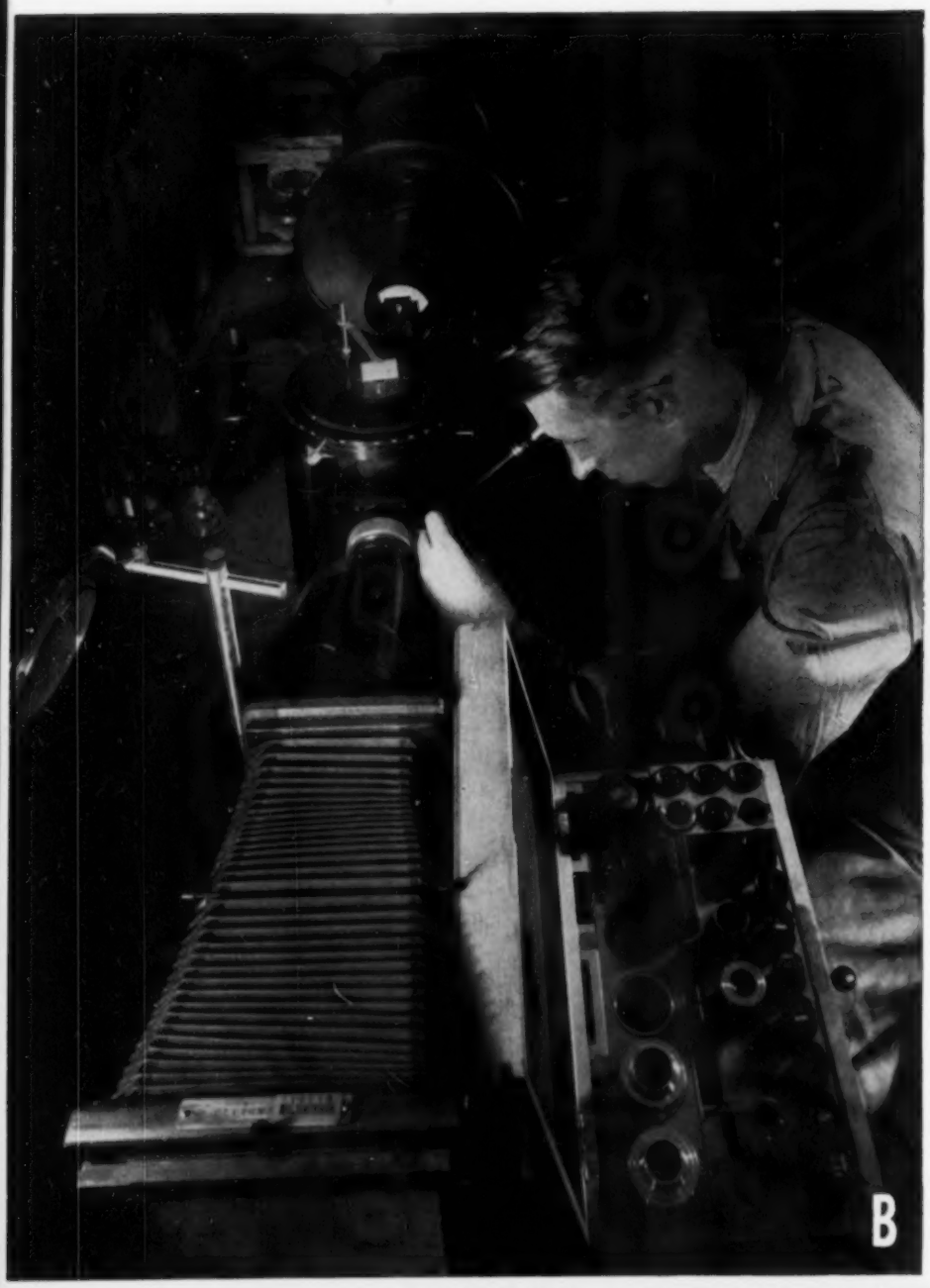
YOUNGSTOWN, OHIO

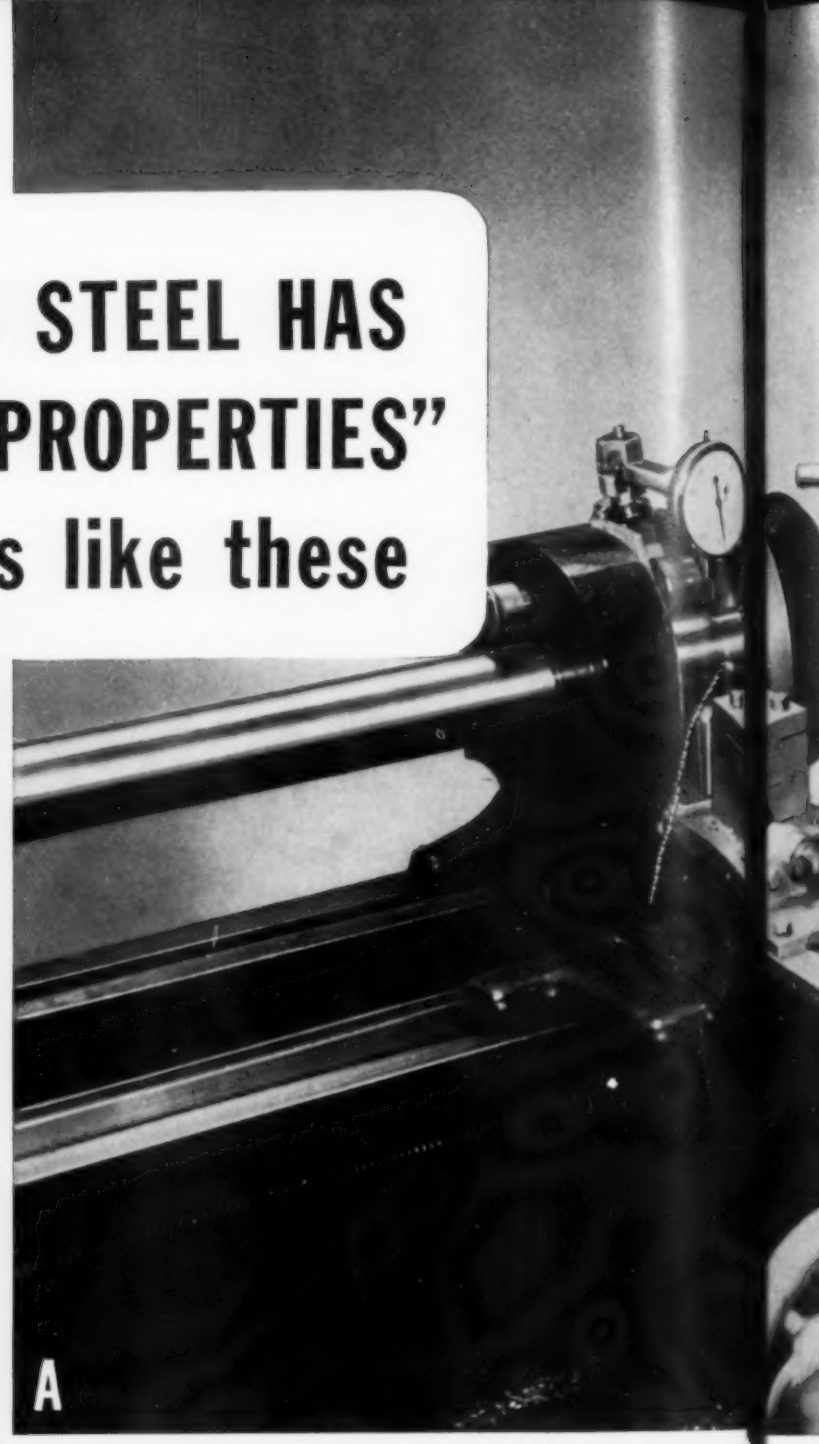
*Canadian Representatives:*
PECKOVER'S, Ltd.
Toronto 2, Ontario, Canada

*Licensor*
MONARCH STEEL COMPANY
HAMMOND CHICAGO INDIANAPOLIS

MANUFACTURERS OF COLD FINISHED CARBON AND ALLOY STEEL BARS!

# Before we say "THIS STEEL HAS *Superior* MACHINING PROPERTIES" we prove it by tests like these



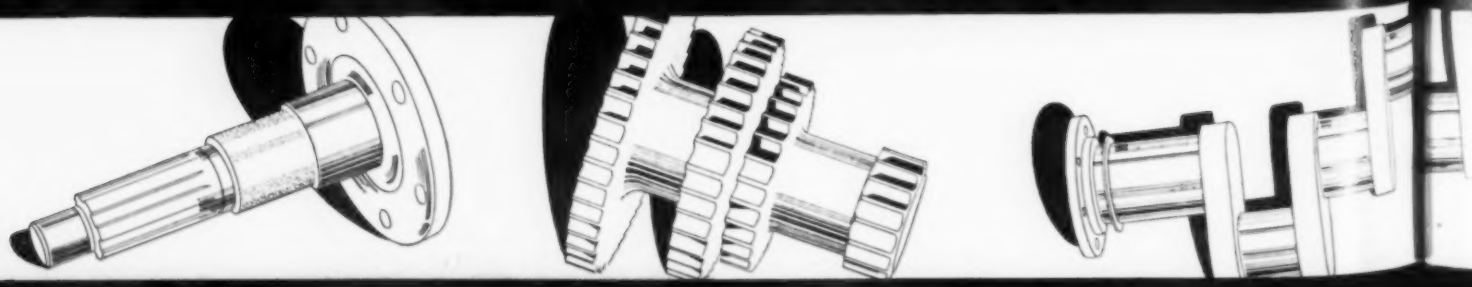

## NOTHING IS LEFT TO CHANCE

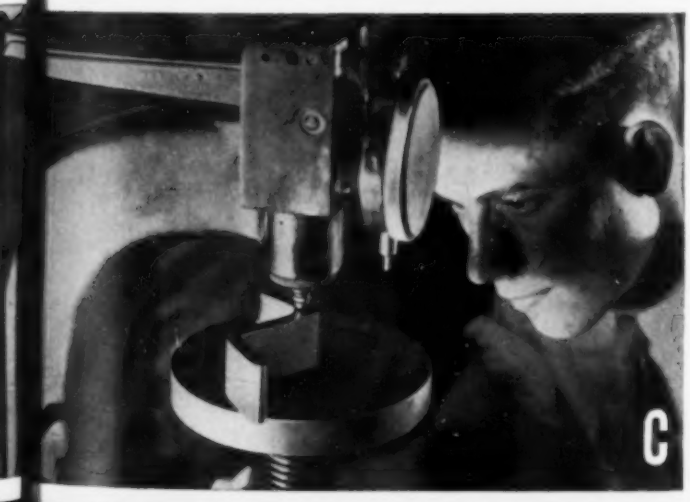
To give you the right steel that will do the best job for you—and to maintain its desirable characteristics in shipment after shipment, precise uniformity of control is exercised in every step, in every heat of U·S·S Carilloy Steel produced. It includes uniformity of selection of scrap for furnace charge, uniformity of furnace practice, uniformity of slag control, uniformity of tapping, pouring and rolling practice, and uniformly close metallurgical control, supervision and inspection throughout the above steps until the steel is delivered to your shop.

* * *

*(A) This unusual lathe test is all important in studying machinability. (B) Metallographic microscope reveals facts about physical structure unobtainable in any other way. (C) Rockwell Test for hardness.*

## U·S·S CARILLOY *Dependable*





*By digging out* the facts that forecast performance, we make sure that U·S·S Carilloy Alloy Steels will function satisfactorily—in your plant and in your product.

YOU never saw a testing device quite like this. It is a development original with us—one of the busy tools in our metallurgical laboratory.

Here is a lathe fitted with ingenious control equipment, by which all operating variables during cutting are kept constant. This permits us to obtain a clear and accurate record of steel machinability.

By actually machining test bars on this equipment, we obtain invaluable comparative data on tool life and surface finish which indicate what production practices will give the user best results and the highest economy in fabrication for any particular application.

We emphasize this test because we believe it is unusual and because it illustrates how far we go beyond the routine physical and chemical check-ups to make sure that our alloy steels will exactly fill the bill for you.

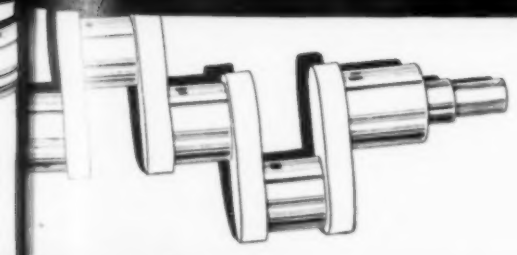
With us, the making of U·S·S Carilloy Alloy Steels is a precise and exacting process. They are produced in a plant especially devoted to alloy steels. Here, the finest and most modern equipment is matched by the skill of experienced mill and metallurgical personnel. Every step in production from furnace to final inspection is on a controlled quality basis. Each order, whether large or small, gets individual care and attention.

To be sure you get the *most* value from your steel dollar, ask our metallurgists to work out the economies of Carilloy Steels as they apply to your product.

**CARNEGIE-ILLINOIS STEEL CORPORATION**
**Pittsburgh and Chicago**

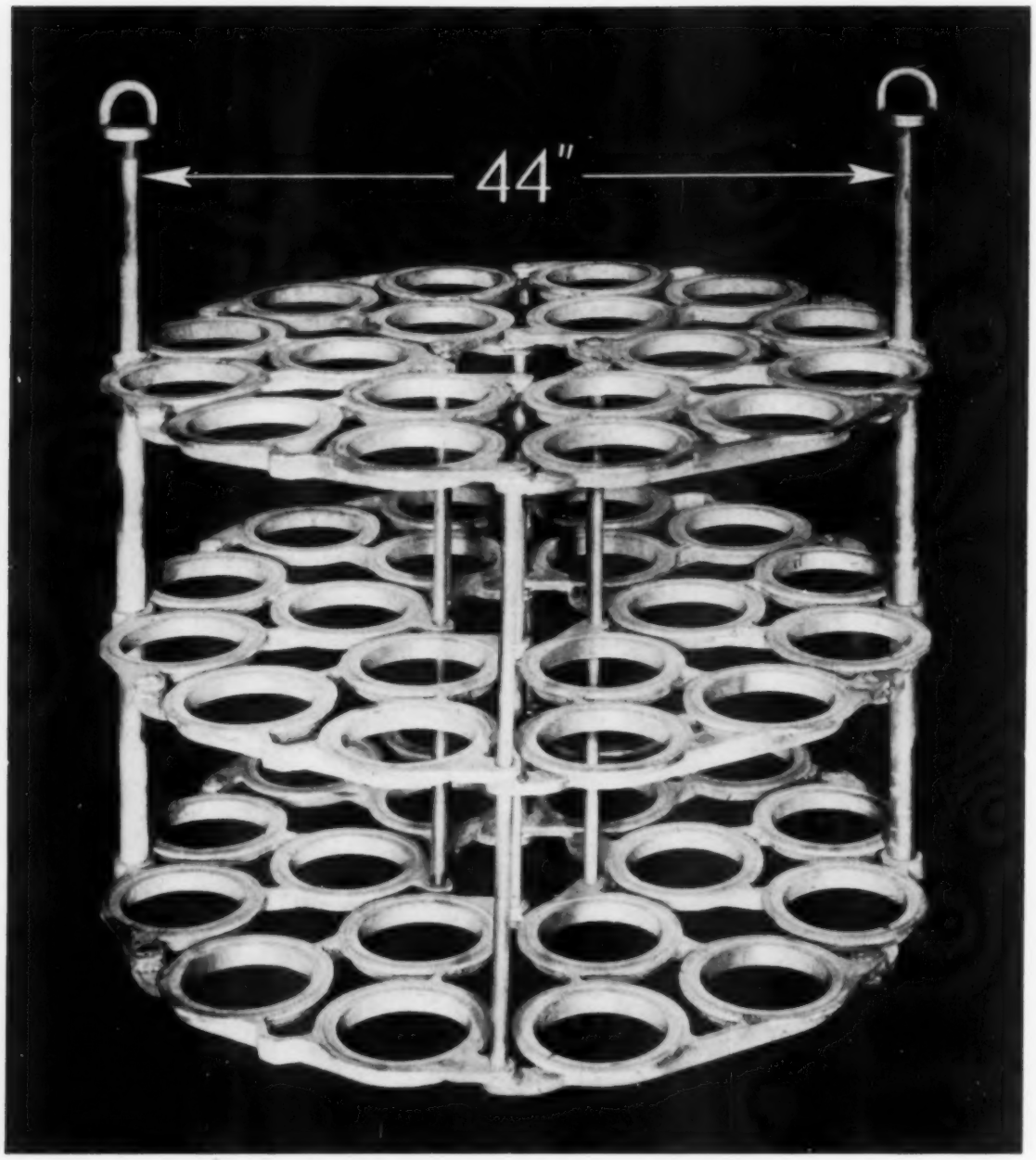
Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

# ALLOY STEELS



USS

# UNITED STATES STEEL




# NITRIDING with EASE

## — — in handling

Only 42 inches in diameter yet it holds 3,000 lbs.

That is the total weight of the airplane sleeves which are placed on this fixture for Nitriding. The main feature of this casting is the fact that these sleeves may be stacked and spaced with ease due to ingenuity of design.

The alloy "Nichrome" in sheet or cast form as Nitriding Containers assures the longest life available for any commercial alloy.

DRIVER-HARRIS COMPANY
HARRISON, NEW JERSEY

TRADE MARK REG. U. S. PAT. OFF.

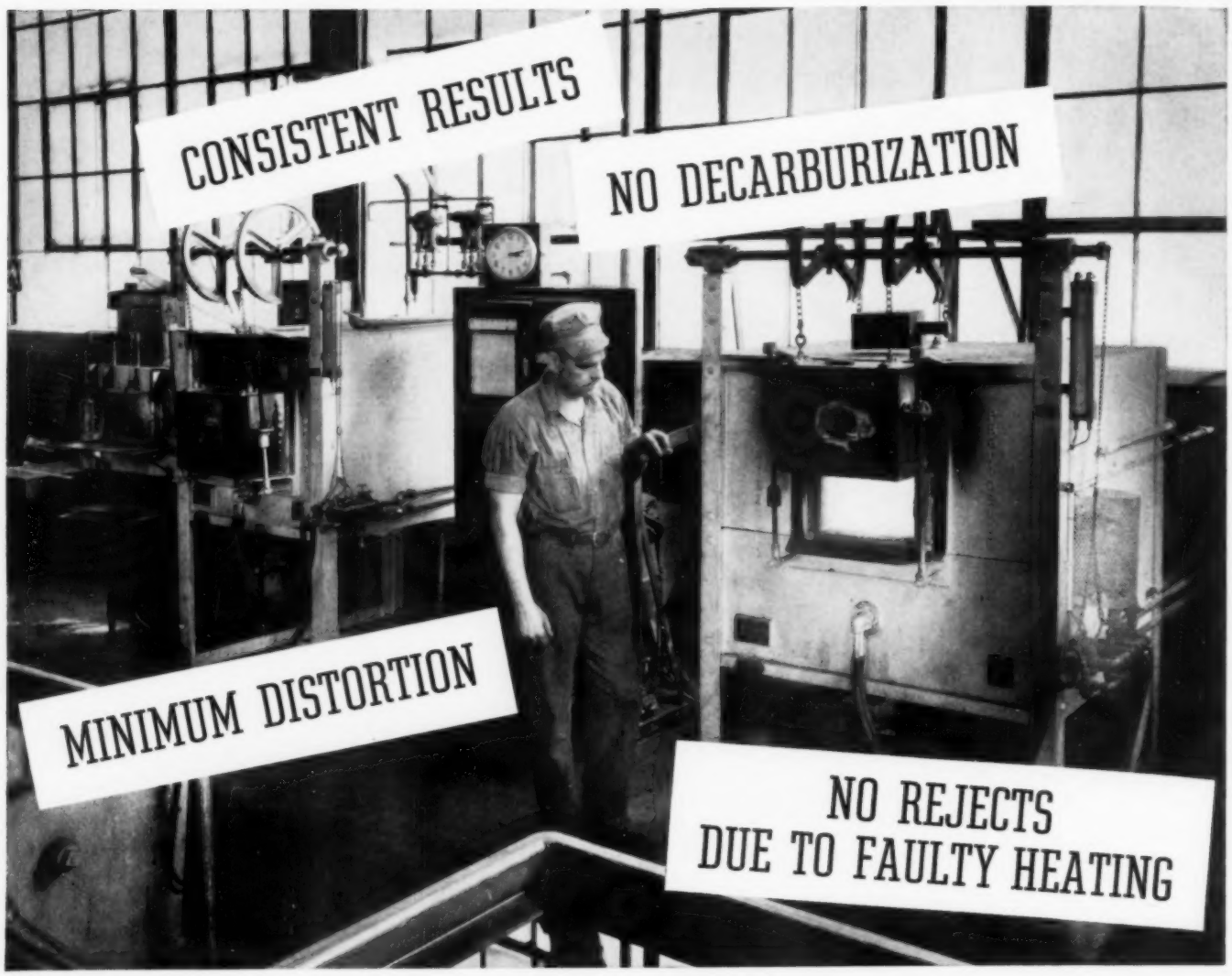
# Nichrome

*The Dependable Heat-Resisting Alloy*

# NORTH AMERICAN
## *for* COMBUSTION

★

# NORTH AMERICAN
## MANUFACTURING COMPANY
## CLEVELAND, OHIO




**THIS IS THE PERFORMANCE STORY OF ELECTRIC HEAT AT THE JEFFREY MANUFACTURING CO.**

• World-famous makers of a wide variety of transmission, conveying, and materials handling equipment, The Jeffrey Manufacturing Co., Columbus, Ohio is an enthusiastic user of high temperature electric heat.

This Jeffrey installation consists of two Hayes "Certain Curtain" furnaces, one is equipped with Globar Brand Electric Heating Elements for high temperatures — the other is a medium temperature furnace for pre-heating.

This equipment is used for hardening tools and dies made of many types of steels including 18-4-1, 12-4-2, molybdenum, tungsten, high vanadium and cobalt high speed steel. The heat treating problems are as diversified as the products the company makes.

No wonder then that Jeffrey is enthusiastic over the fact that it can report consistent results in hardening tools, without decarburization, with minimum distortion and with no rejects due to faulty heating.

Let our engineers show you what "Globar" elements and electric heat can accomplish in *your* plant.

GLOBAR DIVISION

THE CARBORUNDUM COMPANY • NIAGARA FALLS, N.Y.

REG. U.S. PAT. OFF.

(Carborundum and Globar are registered trade-marks of and indicate manufacture by The Carborundum Company)

MEMBER

## *and retain its stainless properties*

We are hardening noncorrosive steels such as 18-8 to a hardness almost equal to that of a diamond.

Rotary paper and cellophane cutters; fiber box edging tools; clock and indicator parts; refrigeration valves and seats; movie camera parts; delicate gears; centrifugal pump impellers, shafts, and rotors that must be noncorrosive after processing will stand muriatic acid 50-50 for twenty-four hours.

The parts must be finished, ground to size, or polished before processing, as

**SUPER SCOTTSONIZING**

can not be ground. No change in hole size; no warpage.

**C. U. SCOTT & SON**

**ROCK ISLAND, ILLINOIS**

*The first commercial steel treating plant in the United States*

# *Welds that equal the Stainless Steel you weld*

Tell your Page Distributor the type of Stainless Steel you want to weld. The Stainless Steel electrode he will supply will give you weld metal that equals the Stainless you weld. You can depend on it.

Each of these Page-Allegheny Stainless Steel electrodes was developed in conjunction with the country's largest producer of Stainless to give you electrodes that

1. *give you weld metal that equals the Stainless you weld*
2. *can be used for vertical, overhead or horizontal welding*
3. *give you better Stainless welds at lower welding cost*

Ask your Page Distributor to give you a copy of the booklet "Page-Allegheny Stainless Steel Electrodes." Get complete information from him.

**PAGE STEEL AND WIRE DIVISION** · MONESSEN, PENNSYLVANIA

**AMERICAN CHAIN & CABLE COMPANY, Inc.**

ACCO

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OWEN SILENT SPRING COMPANY, INC.
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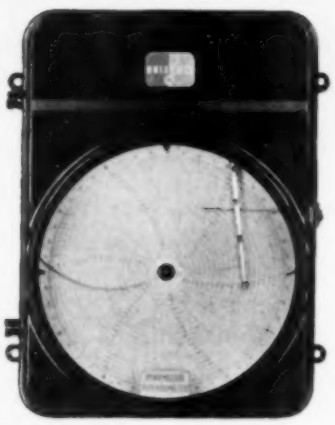
*In Canada:*
DOMINION CHAIN COMPANY, LTD.
*In England:*
BRITISH WIRE PRODUCTS, LTD.
THE PARSONS CHAIN COMPANY, LTD.

# SHOCK.. POUNDING.. VIBRATION

## CAN'T DESTROY PYROMASTER ACCURACY!

Again Bristol's Pyromaster Potentiometer Pyrometer Controllers demonstrate ability to maintain correct furnace temperature even under terrific vibration from nearby giant hammers.

Two of the seven Bristol's Pyromaster Potentiometer Pyrometers installed on billet furnaces in the plant of the Vulcan Crucible Steel Co., Aliquippa, Pa. Although several giant hammers are at work only a few feet away, these Pyromasters have given accurate furnace temperature control from the day they were installed!



**ONLY A PYROMASTER HAS ALL THESE FEATURES!**

No motion until motion is called for. Simple. Lightweight. Compact. Fewer moving parts. Less wear. No need for stocking replacement parts. Quick response to temperature change. Charts easy to read and file. Jewelled galvanometer. Completely balanced. Operation in any position. Vibration-proof.

WHAT TEST could be tougher for a pyrometer than to team up with thundering giant hammers?

In the forge plant of the Vulcan Crucible Steel Company, seven Bristol's Pyromasters on the billet furnaces are up against terrific vibration and shock hour after hour, day in and day out. Yet each Pyromaster operates perfectly — with an absolute disregard for vibration!

A Pyromaster will give you, too, the same reliable performance. For temperatures up to 3300°F. Write for Bulletin 507 H

THE BRISTOL COMPANY, WATERBURY, CONNECTICUT

BRISTOL'S

TRADE MARK REG. U.S. PAT. OFF.

# *Notes on*

# Contributors

THE shirt-sleeved gentleman in the work-a-day background is **Harold S. Austin,** foundry metallurgist for Buick Motor Division of General Motors. His experience in the metallurgical field extends over a period of 30 years and includes a chemical engineering degree from Rose Polytechnic Institute and early training with Laclede Gas Co., Peoples Gas Co. & Underwriters' Laboratories, Midland Steel Co., Lackawanna Steel Co., American Steel Foundries, and Hubbard Steel Foundry. From 1919 to 1935 (when he became associated with Buick) he was chief chemist and metallurgist with the Campbell, Wyant & Cannon Foundry Co.

Brought up on liberal doses of ferrite and alpha brass at Cooper Union, **Joseph B. Kushner** became interested in metal plating and finishing shortly after graduation in 1933. First experiences in this line were with Weisberg, Inc., A. Robinson & Son, and Bulova Watch. For the past year he has been doing consulting and research work and is quite enthusiastic about his "assayed plating solutions" and the "selectroplater", a selenium plating rectifier. Assorted hobbies of photography, chess and song writing occupy his leisure time.

**I. A. Rohrig,** a member of the Executive Committee of the Detroit Chapter, has been employed by the Detroit Edison Co. since 1930. In 1933 he received a bachelor's degree in metallurgical engineering from the University of Detroit. His position since 1937 has been research engineer, doing metallurgical work, in the chemical division of the research department.

Another active member is **George K. Dreher,** who has served on the Executive Committee, as vice-chairman, and as chairman of the Milwaukee Chapter. Born in a house alongside the engine room of the Calumet & Hecla No. 2 shaft at Calumet, Mich., his early impressions were of the copper industry. Since 1929, Mr. Dreher has been with Ampco Metal, Inc., makers of high grade copper-aluminum alloys (adv.) first as shop development man, becoming superintendent in 1931 and plant manager in 1936. He has seen the plant grow from ten men to over 250, and while he modestly admits that the surface has merely been scratched as far as research in the aluminum bronzes is concerned, he feels that Ampco's metallurgically controlled plant is leading the way in this type of production.

**Robert F. Mehl** has been so prolific a contributor to technical sessions and publications that his career should be fairly well known to METAL PROGRESS readers. For those who wish to refresh their memories, it was outlined in the February 1939 issue in connection with a paper on Recrystallization, and is included on the backs of numerous convention preprints written during his eight years as director of the Metals Research Laboratory and head of the Department of Metallurgical Engineering at Carnegie Tech.

Co-author **Gerhard Derge** was born in Lincoln, Neb., in 1908. His B.A. is from Amherst (1930) and his Ph.D. from Princeton (1934). Among the assignments he has worked on at the Metals Research Laboratory have been a crystallographic study of reaction mechanisms in solid metals and a tin research project.

HAROLD S. AUSTIN

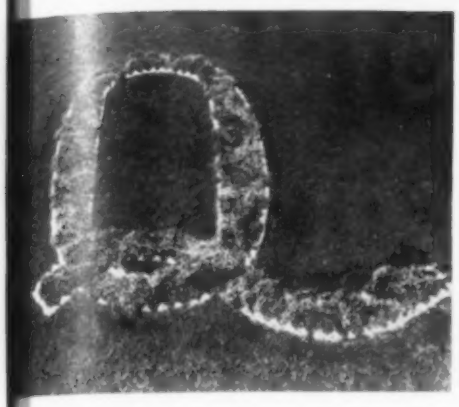
JOSEPH B. KUSHNER

I. A. ROHRIG

GEORGE K. DREHER

GERHARD DERGE

# Merry Christmas to All



## SAY IT WITH FLOWERS

WE have a letter from our friend Kenel ————, patrician Frenchman, via Switzerland. The 7th generation of champagne growers whose product is honored and sung in France, Kenel's youthful heart at 75, his unquenchable spirit, is of unconquered France. Much we cannot print, —some is pathos, some defiance, but a postscript carries that humor which marks men of guts and genius. It reads, "My wife's cousin has a fat little farm at ——— ———(occupied by Germans), he is 83. When the first Boche came he shot two Boche motorcycle scouts from a haycock, undetected, said to his wife, 'now I have no bullets with which to kill, we must plan to live.' So in the five hours before the Boche legions came he traded his pigs, —even Felice, who roots his truffles, to the neighbors for their barnyard manure and behind his house heaped a huge pile. 'He is crazy', cried the neighbors, 'pigs we can kill and hide'. Then the Boche took all the neighbors' pigs. They left only manure. Joking, 'when winter comes you have much to eat'. Cousin is stupid like a fox. In his wine cellars, which the Boche emptied, he now grows with his manure 200 kilos daily of mushrooms, — everybody eats plenty. Many may starve in France this winter, — not cousin Jean and friends." (Another smart guy "on the spot" *engineered* his way out. What is just manure to one man makes three square meals for another.)

SHOWN herewith is a "Spiralink, Jr." belt type furnace hearth, which replaced one of those "stretchy wire" belts at Switzer Cummings Manufacturing Co., Indianapolis, in a Surface Combustion Furnace. Other Surface Combustion furnaces come equipped with Spiralink. Weight 10 pounds per square foot, one half the weight of competitive cast belts, "Spiralink, Jr." lives three times the life of wire belts.

SAILED recently with Alvan T. Simonds (President of Simonds Saw & Steel), on his new motor sailer the "Verlaine", "wonder yacht" equipped with all gadgets from hot and cold running doorknobs to steam heated toilets. Alvan was venting his righteous indignation against mink in general and Cape Cod mink in particular. Alvan has bought many a sable, but now he is gagging on a paltry 100 mink. "How in hell can I spot a mink from an airplane" says Alvan, then tells this story:—

ALVAN, with pontoons on his Wasp Stinson, drops into a Cape Cod pond near Hyannis to absorb some cocktails at a friend's 30 room bungalow. Gunning the plane for a landing, they glide in low over Mrs. Muriel Maginis's mink ranch which borders the pond. Things then begin to happen in following order:— Airplane scares mink. Scared expectant mother mink run wild, jettison cargoes of baby mink. (We learn that mink abort and evacuate when in danger.) Mrs. Maginis promptly sued Mr. Simonds for blighting her mink crop by 100 mink, 50 of which she says are pelts at $25 and $50 of which are breeding stock at $100 per copy. "Heck," says Alvan, "looks like I am stuck, but how can anybody but a mink tell which mink are good for breeding purposes?"

WHEN Alvan faces that Cape Cod jury he is undoubtedly going to buy a lot of mink. You can look for higher saw prices in the immediate future. Later Alvan was practicing with golfer Walter Hagen on the 19th hole, made same in par 5. Hagen, with 7, grabbed his hat and dashed out. "Hey! where you going?", called Alvan. "I am going to trap myself a bit of fur," cracks Hagen.

PLEASE don't presume that because the biggest furnaces have General Alloys X-ite parts we don't do the small jobs too. The six box type furnaces shown are a few of many electric furnaces built by Harold E. Trent Co., Philadelphia, and equipped with Q-Alloy and X-ite hearths. These shown are rated 18KW at 220 volts. Inside dimensions are 15" wide by 12" high by 20" deep. They are equipped with automatic control. Harold E. Trent doesn't compromise with quality.

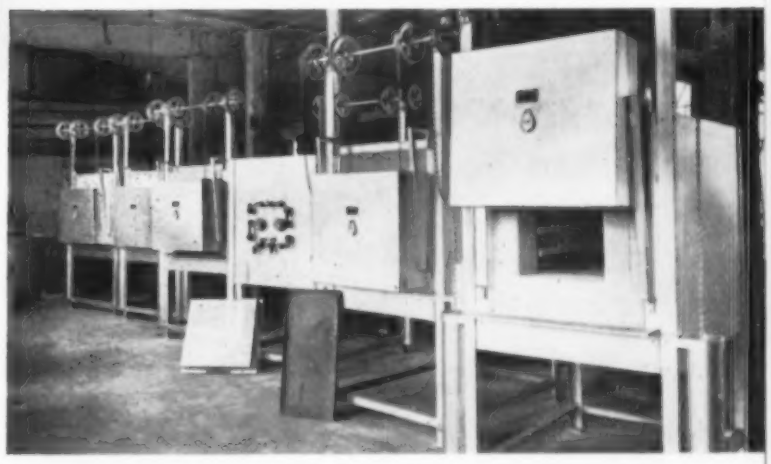
FED on propaganda and rumor we figured the Dutch were 50% chummy with Hitler, that the "5th column party" had the next election in the bag. At a Dutch dinner in New York we learn,—praise the Dutch,—some interesting truths:—

1. The Moerdyk Bridge, largest bridge in Europe, over which Nazis invaded Holland, was mined with dummy explosives. The officer in command was brother of the Head of the Dutch Nazis.

2. Twenty minutes after Holland surrendered, the Germans bombed Rotterdam, killing 30,000 people, wounding 70,000 from wave after wave of low flying bombers. There was no warning, no defense. The Dutch,—below sea level—had no cellars to hide in. Germans accurately bombed around everything they wanted, leaving all bridges, food warehouses, fuel depots intact.

3. Dutch East Indies got cabled advance dope 2 hours ahead of the German invasion of Holland. In the 2 hours they: A. Jugged all Germans. B. Captured 20 German vessels intact. C. Tossed would-be 5th columnists in the klink.

GOING SOUTH? IT'S A GOOD IDEA.



WITH 20 new stainless steel submarines, fast torpedo boats and fine harbor defenses, the Dutch East Indies, say our friends, need just a few more airplanes to be "Jap Proof". There are 10 million Chinese—only 7,000 Japanese, 80,000 whites in the Dutch East Indies. Dutch say the Japanese can't survive in their climate for more than a few years.

TOM FRANKS, Sales Metallurgist in our Chicago office, has just committed matrimony. He will be walking on his heels for a few weeks. Customers' indulgence will be appreciated.

This is an advertisement of General Alloys, oldest and largest manufacturers of corrosion and heat resistant castings, headquarters in Boston, Mass., with offices and agents in principal cities. General Alloys is unique in its product as it is in its advertising. To every member of A.S.M. and reader of *Metal Progress*, we wish a Merry Christmas and health, happiness and prosperity in 1941.—H.H.H.

Q-ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

# HERE'S SOMETHING

**THESE ARE ADDITIONAL FREE-MACHINING STAINLESS BENEFITS**

- ★ Better Finishes
- ★ Fewer Shop Delays
- ★ Less Galling or Seizing *(both in production and service)*
- ★ Longer Tool Life
- ★ Faster Grinding and Polishing
- ★ Lower Cost per Unit of Product
- ★ Standard Tooling Set-ups

**TALK ABOUT TOUGH MACHINING!** How would you do at machining these dental instruments from your stainless steel? Would it be a headache? Yet, the manufacturers do it every day on a commercial scale—even though some of the instruments are made from a stainless that can be given a tool steel temper. Their secret is the proper selection of the Carpenter Stainless Steel that gives just the right balance of easy working qualities and resistance to corrosion.

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*Starting Today*

## To Speed Production of Stainless Parts

Here is a suggestion that is just as practical as it is easy to follow—and it will help you boost output and reduce unit costs in producing machined stainless parts.

It is simply to ask yourself, at the right moment, this 7-word question—

"Why not use Free-Machining Stainless, here?"

If you can't think of a good answer to that one, you are in the clover—with an opportunity to speed up stainless machining 15% to 50% by merely scrawling, "Make it of Carpenter Free-Machining," on the blue print.

And that is all there is to it—simply making sure, *before* you order the stainless, that you are not letting an opportunity for getting the most out of your production equipment slip by.

Sometimes, of course, you *will* find good reasons for not using Free-Machining Stainless Steel. But free-machining grades are priced only 3% to 8% higher than other grades, are fully as corrosion and heat resistant, and have parallel physical properties. So, ordinarily it is simply the lack of a routine check-up—either in the drafting room or purchasing—that is preventing your plant from cashing in on Free-Machining Stainless Steels.

Carpenter has prepared, for your convenience, a handy pocket guide to help you answer the 7-word question—and make routine check-up easy. It is a Stainless Steel Selector Slide Chart that will help you put your finger on this and the dozens of other profit opportunities that lie in the proper selection of stainless steels. We will be glad to send you, without obligation, a free copy of this slide chart. Simply mail the coupon below.

more than corrosion resistance

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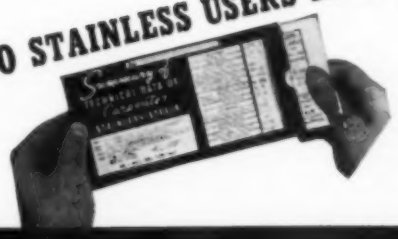

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Gentlemen: Without obligation, please send me my free copy of your Stainless Steel Selector Slide Chart.

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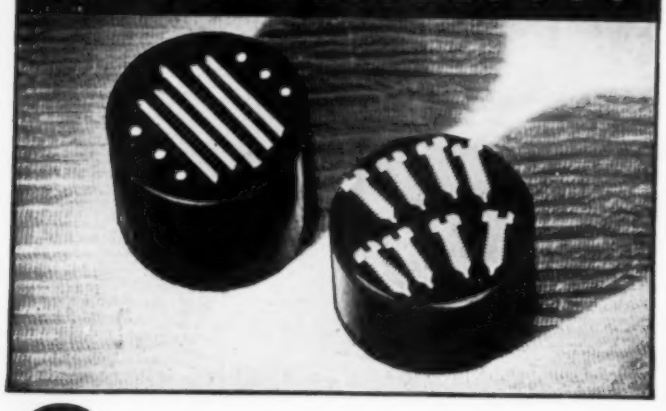
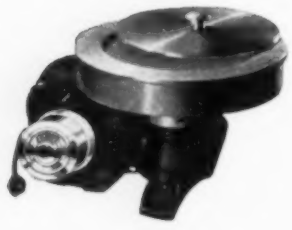
IN METALLURGY . . .



# AB SAMPLE PREPARATION EQUIPMENT IS USED EVERYWHERE



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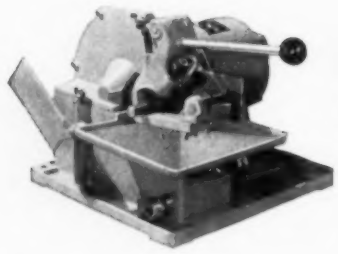

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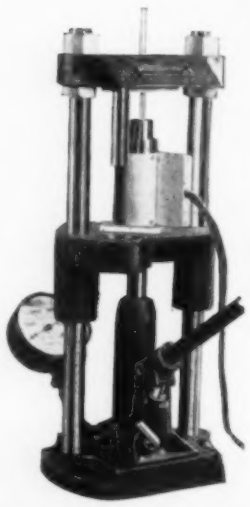

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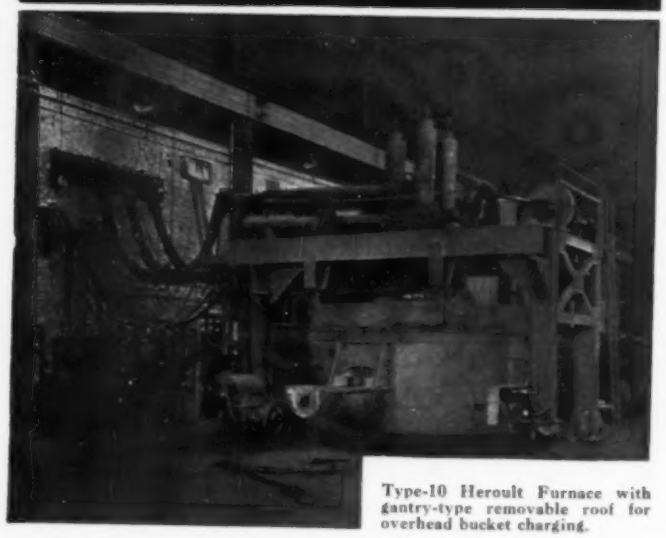

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**Some of the other advantages of flame-cutting are:**

***Operators*** of flame-cutting machines can be trained to do good work in a short time. The investment for equipment is moderate.

***Less Dependence*** on outside sources of supply for fabricated parts is made possible by ability to make what you need as you need it.

***One-of-a-Kind*** production for replacement or new-model development work is economically practical with flame-cutting, and is usually much faster than by other methods.

***Parts Inventories*** can be held down, because almost any parts can be produced immediately as needed from stock steel.

***Savings in Weight*** and bulk, and in most cases, increase in strength over parts fabricated by older methods are made possible by the use of flame-cut and welded parts.

***Design Changes*** can be made quickly, without loss of time or money for new dies, molds, or patterns. Change-overs on flame-cut parts are only a matter of minutes.

***Semi-Automatic*** cutting can be done by using easily fabricated templets which guide the blowpipe. The operator can also "hand trace" direct from a drawing.

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The Linde organization can supply you with small portable or large stationary flame-cutting machines. You can also obtain from Linde—oxygen, acetylene, carbide, and other essential materials for using flame-cutting, with the assurance of dependable, uninterrupted deliveries.

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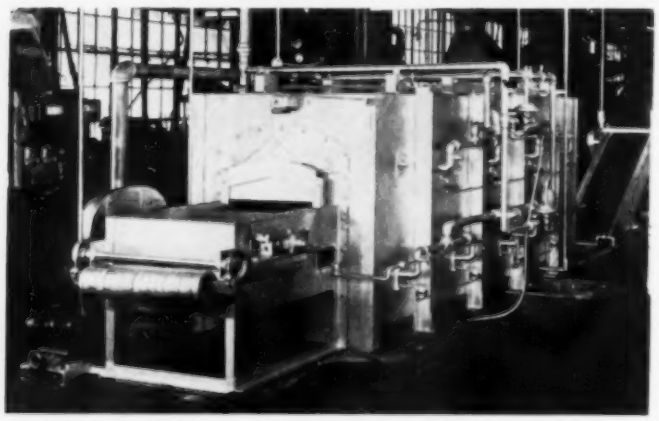

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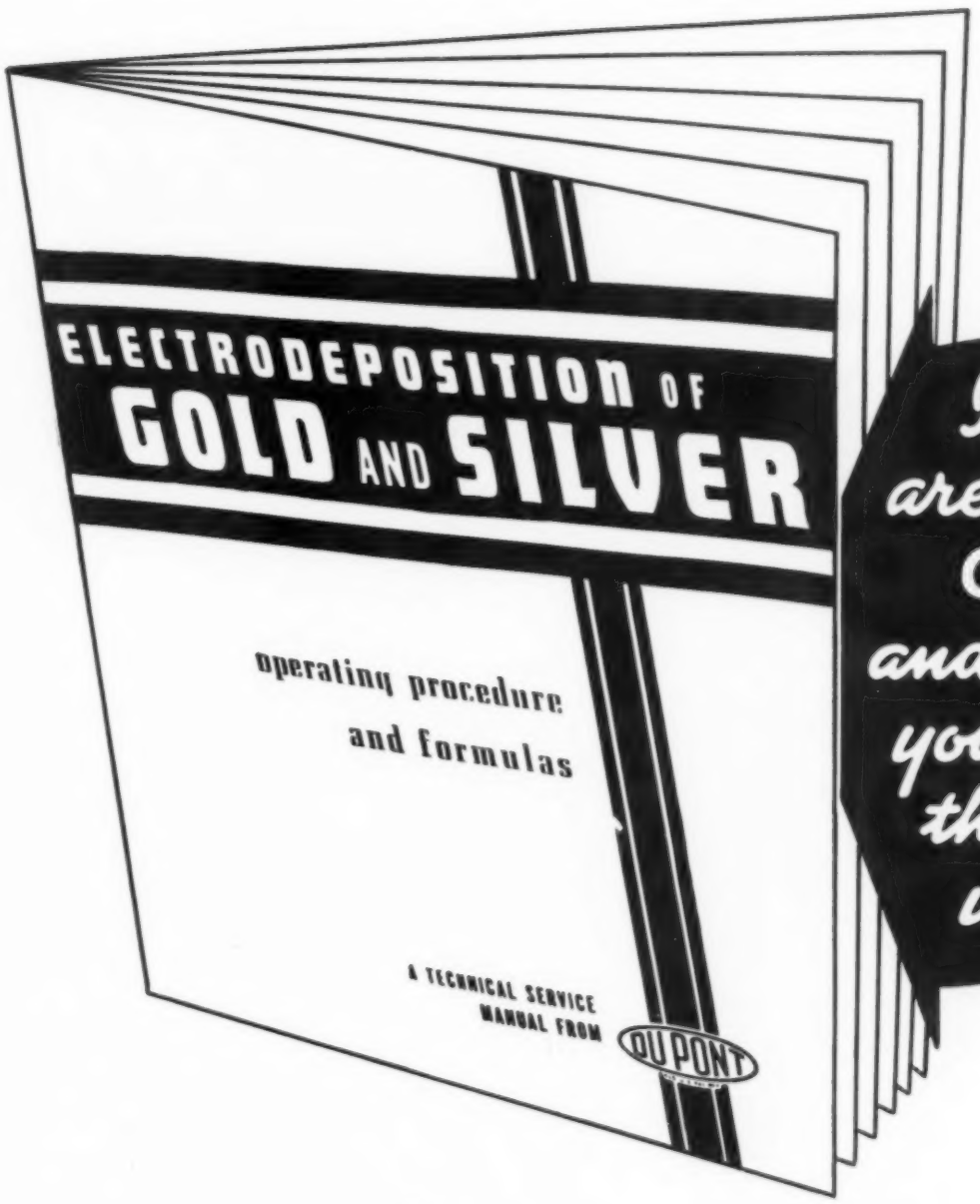


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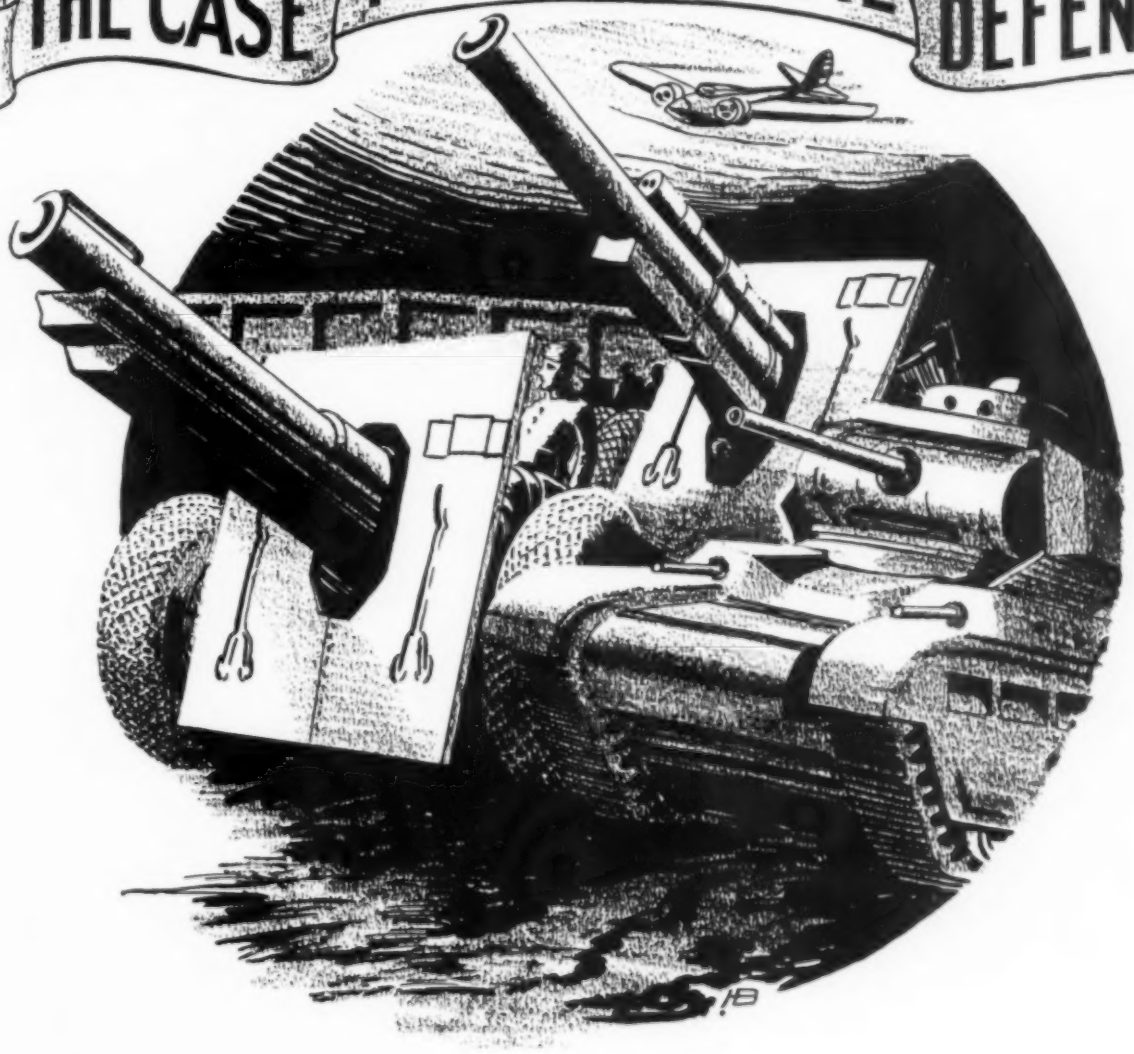

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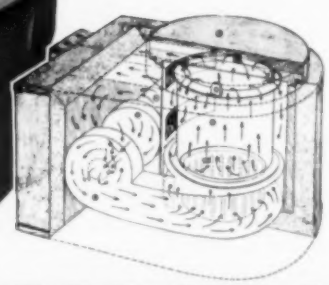

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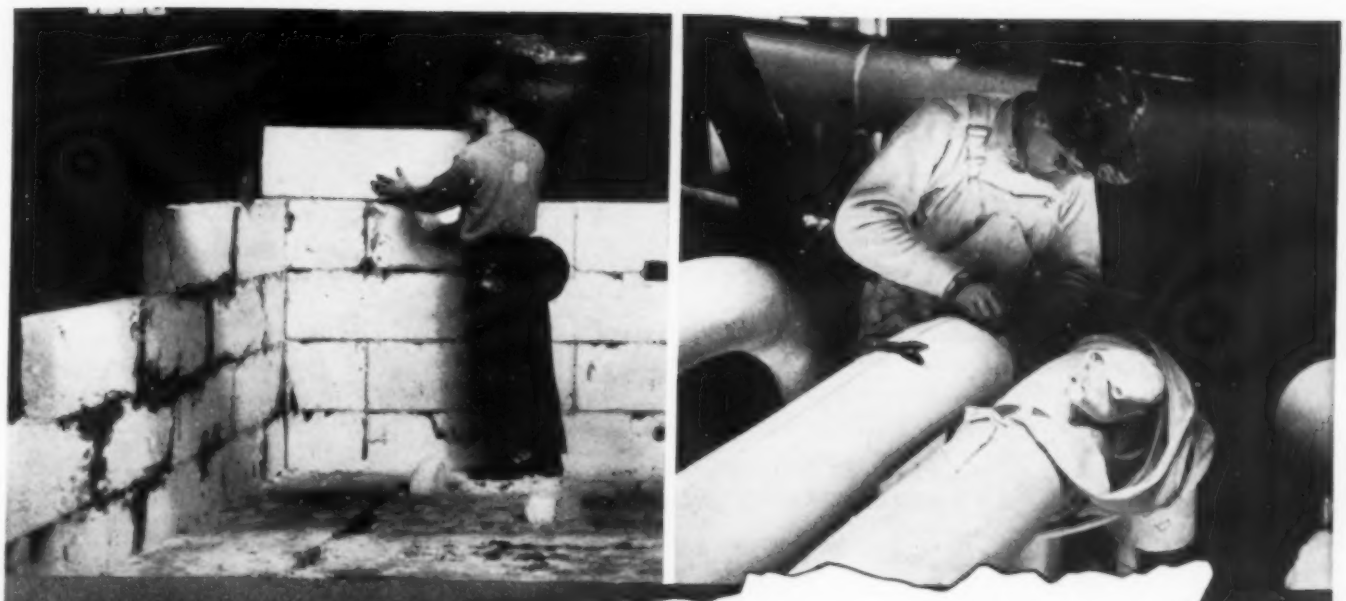

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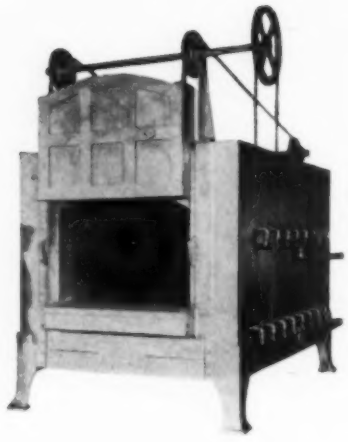

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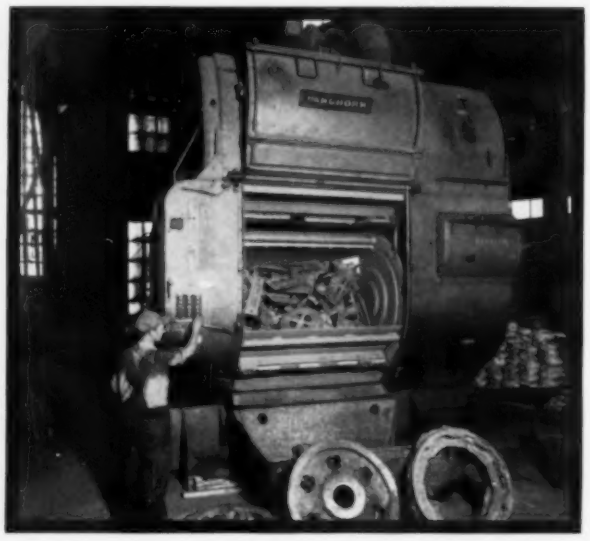

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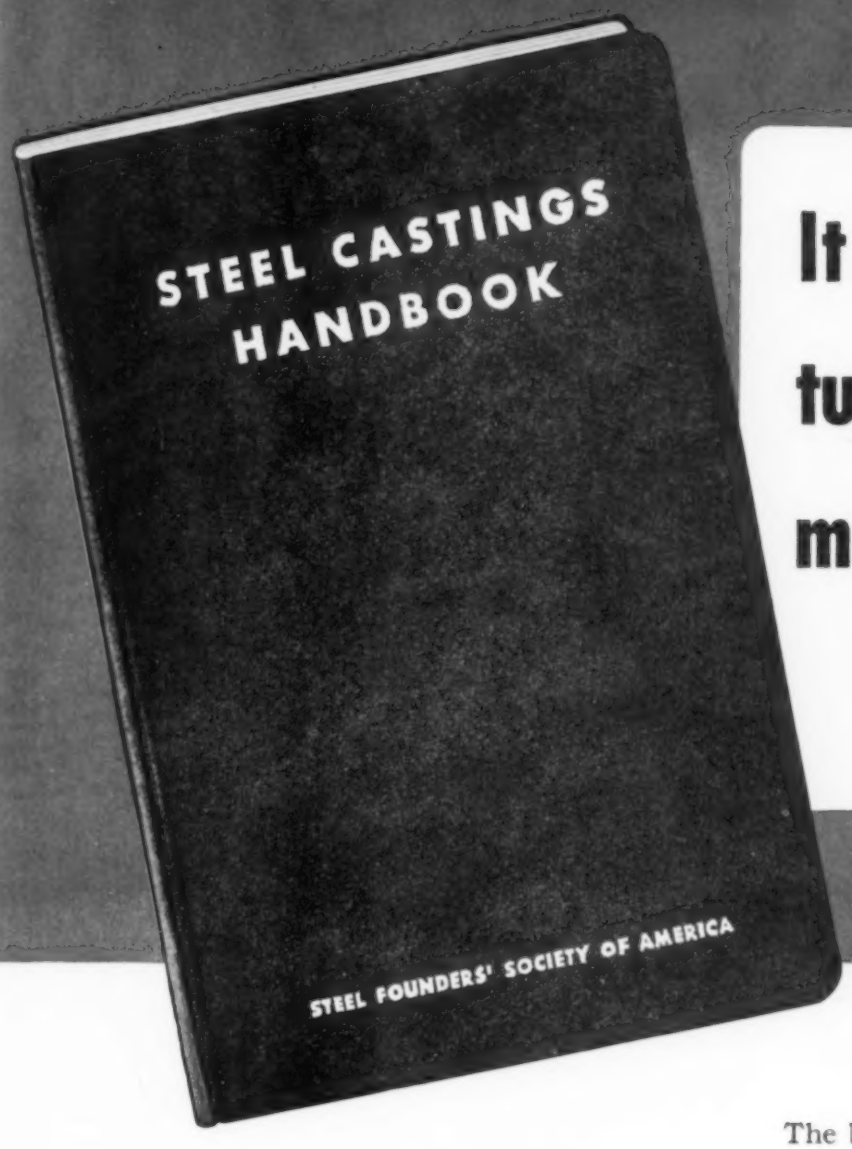


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# Plastic Deformation

*(Continued from page 808)*

slippage has occurred by several atom spacings the "fit" between like atoms may be increased. In other words, the total amount of atom misfits or displacements for the two layers may be reduced, in which case it will be harder to continue the shear. The material will, in fact, have been strengthened by slip on the crystal plane. Potential energy will have decreased, and the shearing strength increased, to be followed at a distance of a few atom planes by another slip.

If there is little impurity, or the temperature is high, no great differences in potential between planes adjacent to each other need be expected, so relatively few shearing or slip planes will actually occur and "block" thickness will be large. But at low temperatures and in the presence of increased impurities, a wider range of existent potentials must be expected, and the number of chances of slip planes forming is increased, leading to closer spacing of slip planes. Heat has the effect of reducing differences in potential between the various parallel planes. Slip starts on planes having particularly high potentials, and continues on those of successively lower potentials.

Now the forces about the atoms of a crystal are three-dimensional and highly directional in intensity variation. Hence any strain on one plane which tends to a better fit on that plane will be accompanied by some tendency on other planes to a better fit. It should not be surprising, therefore, that the planes of no motion, or of little motion, should be strengthened by slippage on the plane of principal motion.

As mentioned by Dr. Hoyt, Taylor speaks of interior "faults" and "cracks" in his explanation of the strengthening due to cold work. If we substitute "mismating strains" for such faults and cracks, and acknowledge that cohesion, though reduced in intensity, is maintained, we are able to arrive at the three-dimensional picture consistent with the known facts about inter-atomic forces.

The picture I have suggested appears to be consistent with all of the observations and gives at least qualitative reasons for the variations which have been observed. It is consistent with a purely elastic movement at low loads. It also suggests directions in which tests may be carried out to improve our knowledge.

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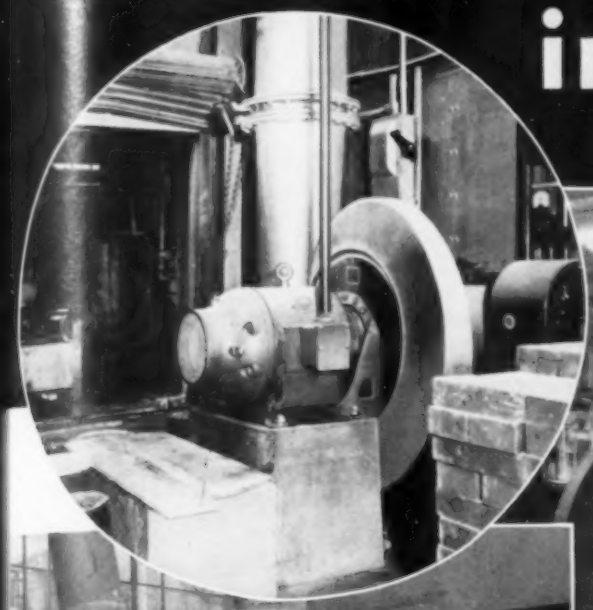

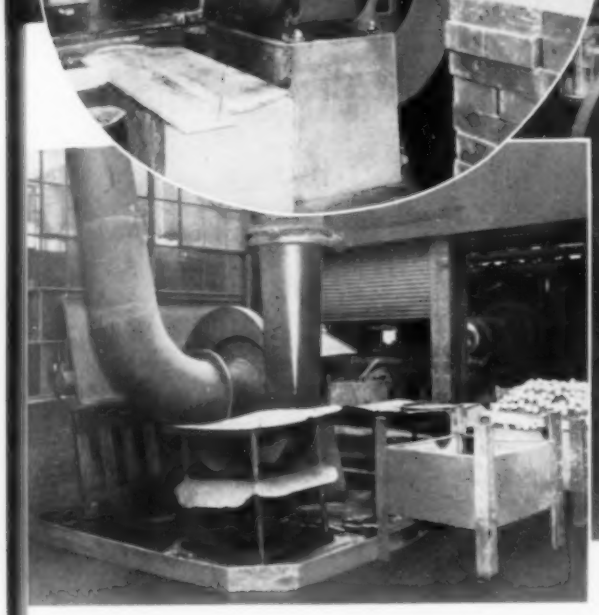

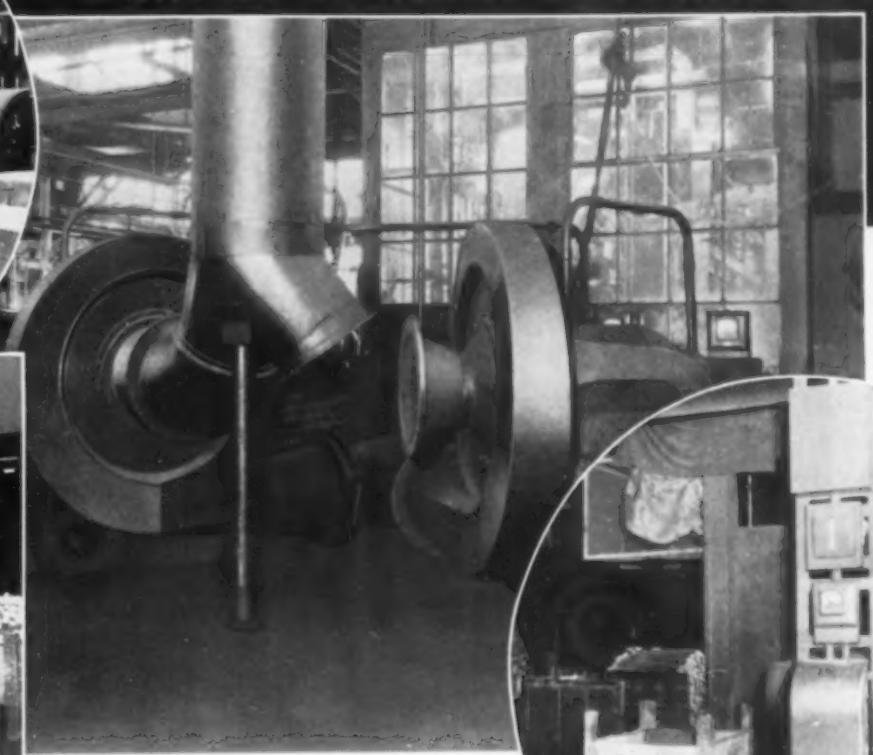

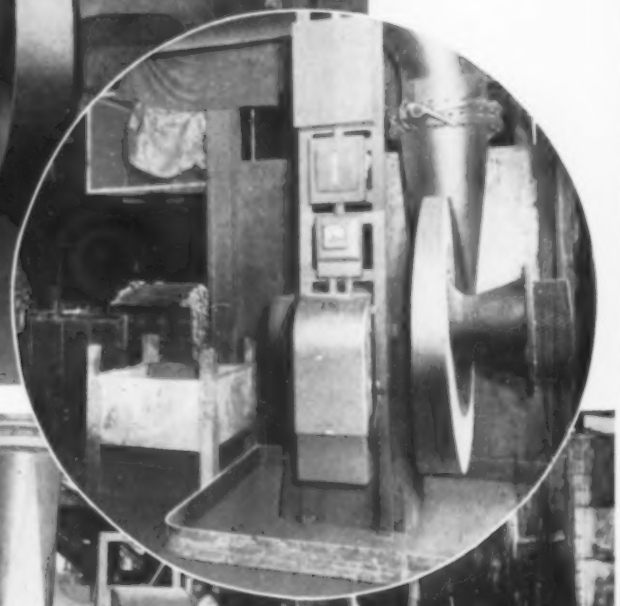

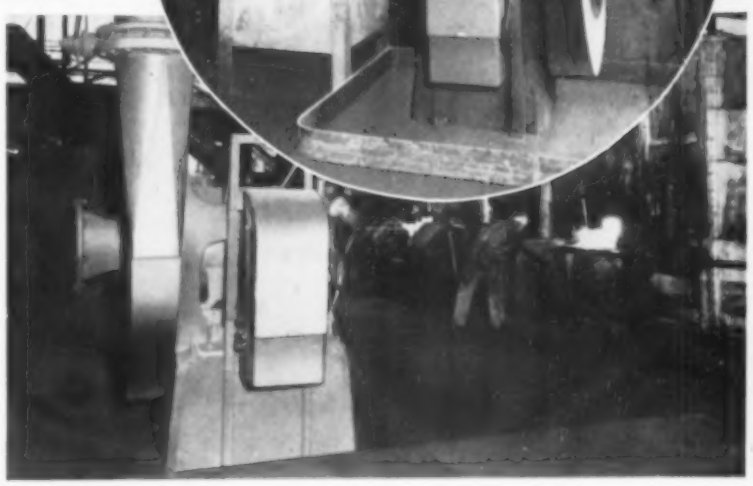

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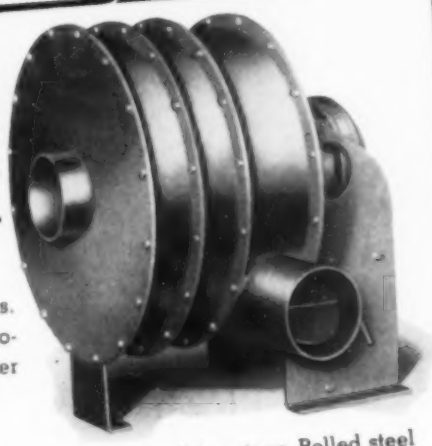

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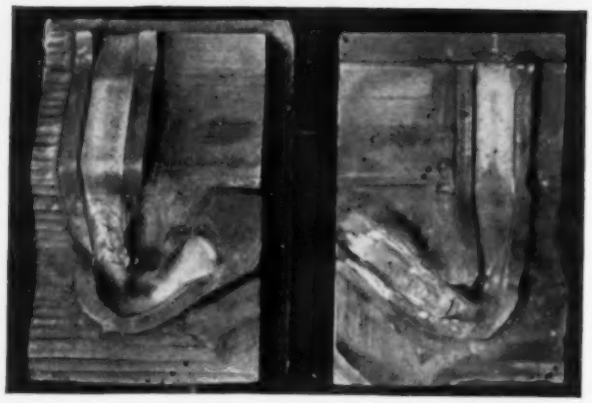

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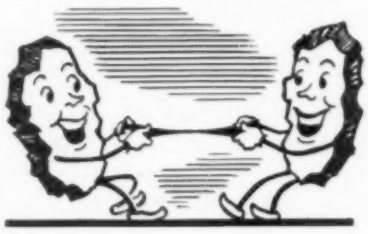

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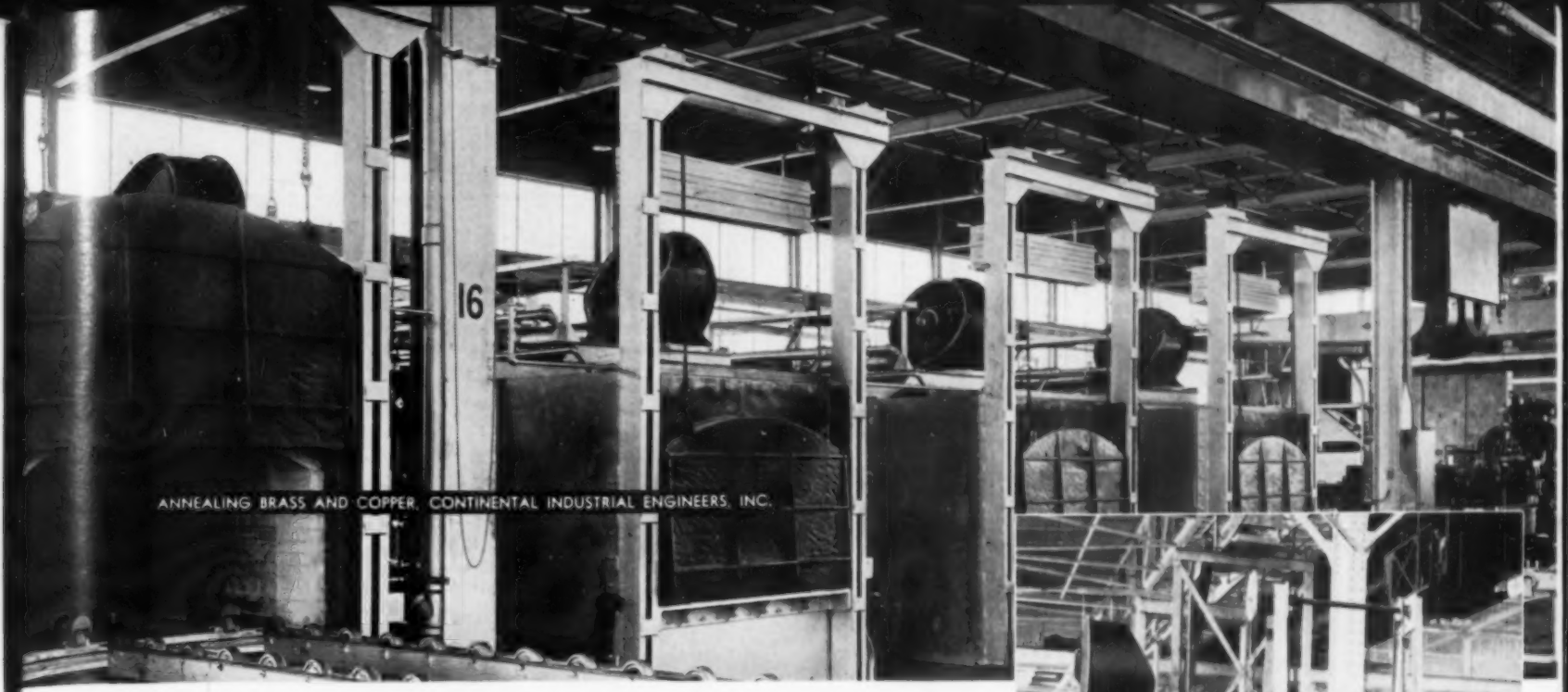


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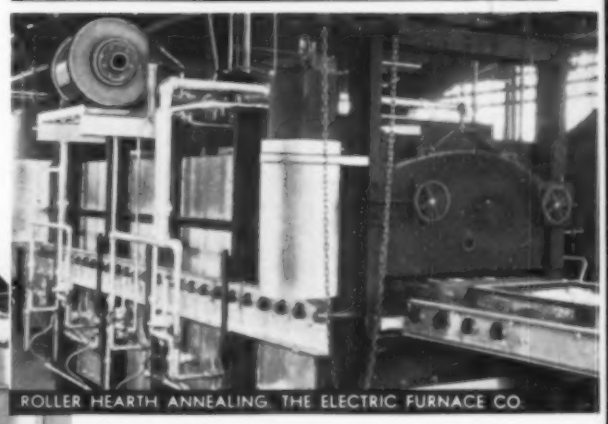

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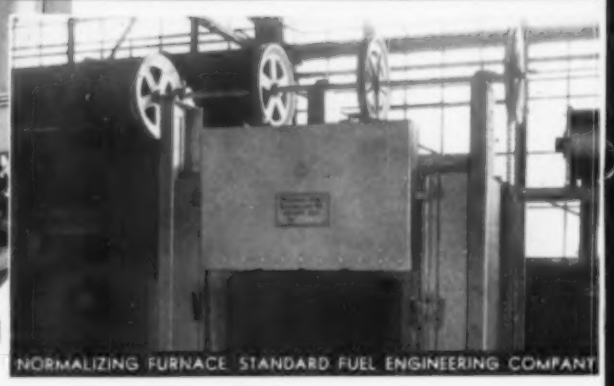

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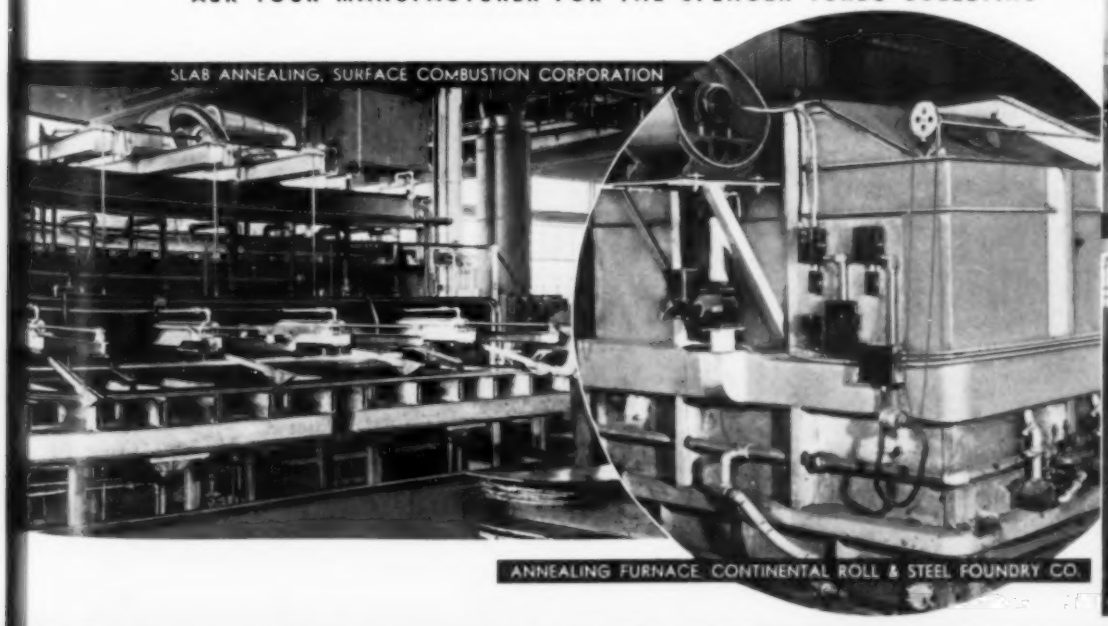

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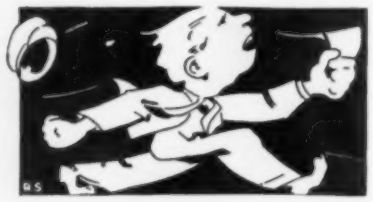

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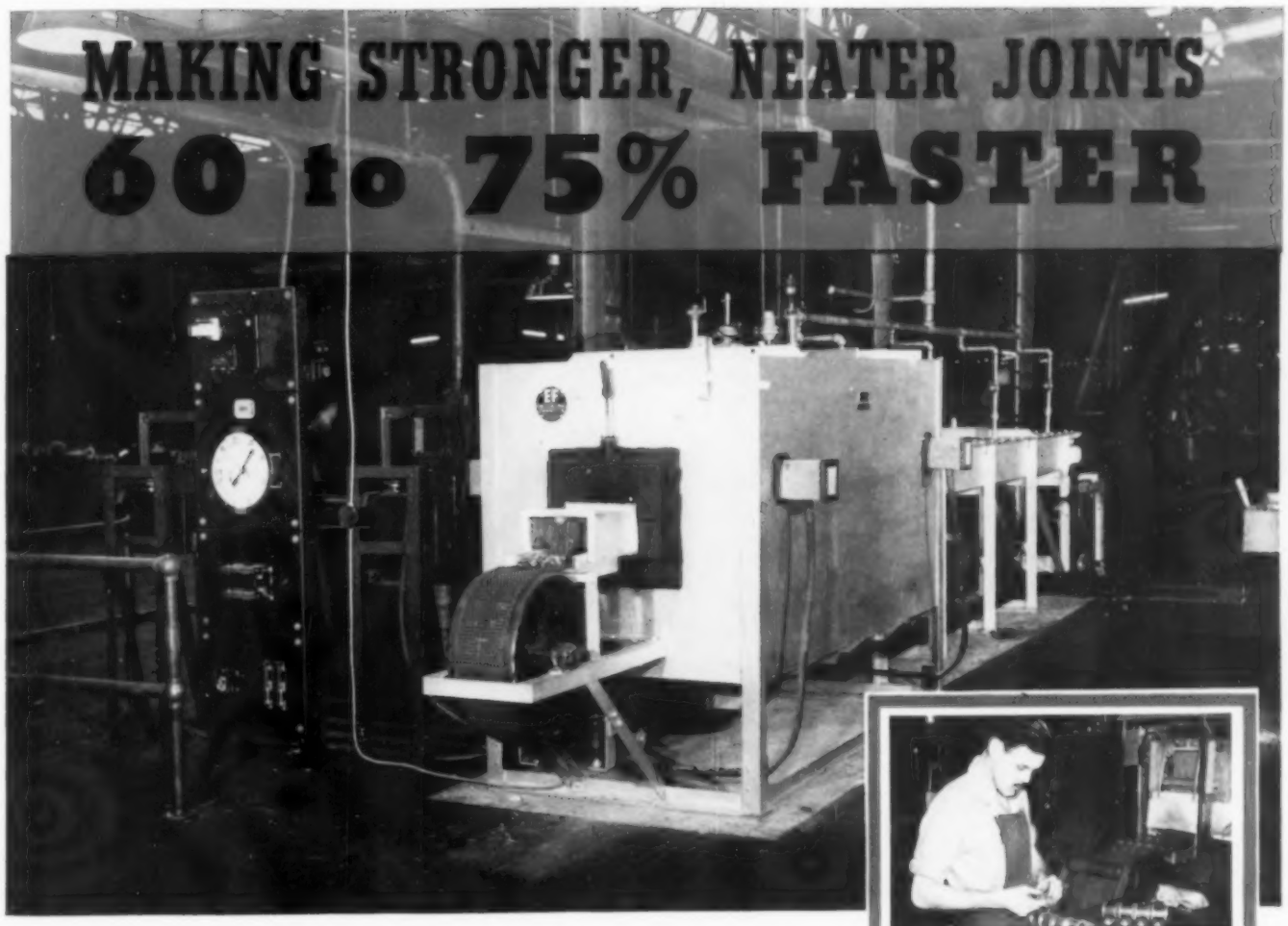

## At 1/4 the Former Labor Cost
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## EF Copper Brazing Furnaces

A large automobile plant installed the above E.F. furnace for joining some of their intricate assemblies. The results proved so satisfactory that within a month after the first furnace was erected they had ordered a second similar but larger unit for handling other parts. The illustration below shows both furnaces, operating side by side—copper brazing all kinds of automobile assemblies, including such parts as clutch throw-out shafts, remote control shift levers, steering knuckle support arm brackets and many other parts.

The Management reports "greatly improved results—neater, stronger joints—60 to 75% faster at about ¼ the former labor cost."

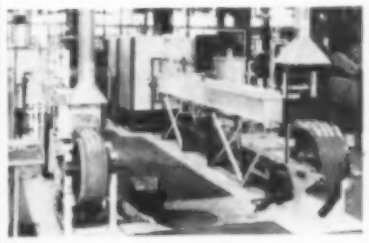
The above continuous conveyor furnace is one of the numerous types we build for the copper brazing process. Other types are handling miscellaneous other large and small assemblies ranging in size from small metal radio tube parts up to large assemblies weighing 50 lbs. or more.

Investigate the copper brazing process. We will be glad to give you complete information, put samples of your products through one of these furnaces to show you the results you can expect, give you an estimate on the cost of equipment to handle your production, together with operating costs, etc. Many prominent manufacturers are now joining their metal parts by the copper brazing process much faster, neater, cheaper and getting stronger joints than they formerly considered possible.



*The operator assembles the parts and places them on the furnace conveyors.*

*The assemblies are discharged at the other end... all units securely and neatly joined.*



*The satisfactory results from the first furnace at left sold the larger furnace at right.*

*Investigate The Copper Brazing Process for Joining Your Metal Parts*

## The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

# Merry Christmas!

Once again, Christmas!

And as the spirit of the season captures us, we feel we would like to clasp hands with each of our friends and say how much we appreciate their friendship . . . how much we value their kindly and helpful cooperation . . . to let them know all the good wishes we have for their health and happiness during this glad season, and for the coming year as well.

But, since most of us dwell far apart, to do this is impossible, so we use the printed word to bring you our greeting . . . a very Merry Christmas and a Happy New Year!

The GATHMANN ENGINEERING Co.

*Emil Gathmann*

President